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Quantification of Residual Timber Values
Northern Model

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QUANTIFICATION OF RESIDUAL TIMBER VALUES

PART I
NORTHERN ONTARIO

EXECUTIVE SUMMARY

This study commissioned as part of Ontario's Forest Values program was designed to achieve two major objectives:

1) to estimate the residual values of standing timber for major industrial uses in northern Ontario;

2) to discover the most important factors influencing these values.

Because economic conditions differ markedly in the north and the south of the province two separate models were developed. These differ in terms of the theoretical underpinnings, the valuation data, and the explanatory variables.

The Northern Model

Theory and Assumptions

The central characteristic of commercial forestry in northern Ontario is the lack of a competitive market for standing timber. The wood supply for northern mills is drawn chiefly from Crown forests and mills tend to be widely separated with long-term supply contracts for specific timber supply areas. Prices are set by regulation at two basic rates according to broad categories of industrial use. In this basic system there is no differentiation based on other economic factors such as stand quality and distance from the mill.

The first step in constructing the northern model, therefore, was to estimate the value of representative sample stands as if there were a competitive market for the timber. this was done by applying the principle of **residual timber value (RTV)**. According to this economic principle, the value of the goods produced from the timber less the costs of harvesting, transporting the timber to the mill and manufacturing the intermediate or the final product, including an acceptable profit at each stage, represents the maximum amount that a buyer would be willing to pay in a market situation. this is summarized in the following equation:

$$RTV = P - (1+PR) * (MC + T + H)$$

where P = Finished or Intermediate Product Price in the market
PR = Profit and Risk Allowance
MC = Manufacturing Cost
T = Cost of Transport from Landing to Mill
H = Harvesting Cost

Underlying the residual value estimations are the assumptions that all RTV is attributable to timber, that the opportunity cost of not employing the other factors of production is zero, and that RTV would become zero should the mill close.

Model Design and Methodology

The Northern model was designed to establish the relationship between RTV and a number of supply side and demand side variables. Regression analysis was applied in this exercise to establish which of the independent variables were more important in determining the RTV.

The initial modelling took into consideration only supply side variables. these included stand and site characteristics, logging system, and distance from mill. Later, demand side variables were added to improve the level of explanation. In the earlier stages of model development MNR districts were used as "dummy" variables. Though these had some interesting impacts on RTV they were excluded from later models because they had little additional improvement in explanatory power of the models. The years in which data were collected were introduced through business cycles of the industries and found to be very important in their predictive capability. In earlier runs Highway Distance to Mill and Non-highway Distance were considered as separate variables but in later runs the two were combined with Non-highway Distance weighted because of its greater impact on costs. The combined variable proved more powerful.

The methodology used to calculate the sample RTVs and estimate the supply side variables was sampling of 1986 to 1991 records in twenty-one MNR district offices throughout northern Ontario. Data forms were designed to record information on harvest volumes, site characteristics, and destinations of mills. Teams of researchers were used to gather the data. product prices and production costs were obtained from a variety of sources, many of them special studies. Often these sources did not cover the entire period and data had to be extended using indices. Logging cost data were available for only one year (1987) and estimated for the other years using indices and moving averages. Price and cost data for groundwood pulp had to be estimated based on kraft pulp data and a confidential estimate by an industry source. Price and cost data for veneer and plywood were estimated on the basis of export data and on factor input costs. Slope, roughness, and underbrush estimates for the logged stands were based on

qualitative assessments by field foresters with reference to a standard classification scheme.

The data were used to operationalize five different models of timber valuation based on key product groupings:

1) Spruce, Pine, Fir
2) Northern Bleached Softwood Kraft Pulp
3) Groundwood Pulp
4) Veneer and plywood
5) OSB/Waferboard.

Stepwise regression procedures were used to weed out less important variables in stages throughout model development. Initial trials eliminated many of the supply side variables. The final configurations of the five product models contain various combinations of three demand side variables and six supply side variables. The three demand side variables represent the linear trend in price over the period of study (1986 to 1991 at the most), a major effect of the business cycle for each product depending on where the starting year for price data sits on the cycle and a minor part of the business cycle (again product specific). The supply side variables are total distance, tree size, slope, roughness, tree height, and underbrush. not all of these variables figure in the final model for each product group. It is of interest that total distance figures in all but the Veneer and Plywood model and the major effects of business cycle figures in all of the final models. The product models were run first on a year by year basis. Later data were pooled across the six year period.

Results

In this study RTVs from the samples between 1986 and 1991 ranged from $30.40/m3 to negative $82.26/m3 for lumber production, from $89.63 to negative 38.08/m3 for species used in kraft pulp production, from $566.13/m3 to negative $28.14/m3 for species used in veneer and plywood production, and from $57.55/m3 to negative $60.48/m3 for species used in OSB/waferboard production. These numbers, however, give only general indications of timber values. In addition to indicating the maximum, minimum and average of RTVs in the samples the models may be used to estimate more specific values relative to distance, stand characteristics, and other parameters.

With respect to ranking the independent variables, the final models based on supply side and demand side variables show that, in the period studied, the variables representing price fluctuation have been the most important for all product groups except lumber. During this period the business cycle alone explained from 48.64% of the variance in residual value of timber

(in kraft pulp production) to 97.5% of the variance in residual value of timber (in OSB/waferboard production). In the case of lumber production, a supply side variable, total distance, proved to be the most important, explaining 49% of the variance in RTVs. When the linear price trend was added 81% of the variance was explained. Other supply side variables that played a role in the final models are tree size, slope and underbrush classification.

Randomly selected ten percent of the collected data had been reserved at the beginning of the project for validation test later on. The reserved data were not used in the process of development of the models. The independent variables for the final models were now supplied from this data base and the generated dependent variables compared with the corresponding data figures. In the case of lumber, kraft pulp, groundwood pulp and veneer & plywood production, 85% or more of the RTVs fell within the 95% confidence interval of the final model results. In the case of OSB/waferboard the figure was 57%.

What do the results mean in practical terms? Adding one kilometre to the transport distance decreased value of standing wood used in lumber production by approximately 13 cents. The effect for the wood used in pulping processes is also negative being approximately 11 cents, and for OSB/waferboard almost negative 12 cents. For every cubic metre increase in average tree size there is a corresponding increase in per cubic metre residual timber value of $16.38 for lumber, $23.13 for kraft pulp, $18.30 for groundwood pulp, and $14.38 for OSB/waferboard. Slope decreased residual values for wood used in lumber and pulp production. Roughness of ground also had a negative impact on values of wood used for groundwood pulp production. An increase in the amount for underbrush was positively correlated with residual values for wood used in veneer and plywood production. This may be because there is more underbrush on better sites. crop height had a positive impact only in the veneer and plywood model.

Strengths and Weaknesses and Model Maintenance Issues

The salient strengths of these models are their flexibility, the rigour of the methodology, and the fact that timber values can be estimated using a relatively small number of variables.

Weaknesses centre on data problems. The research teams had difficulty obtaining accurate volume data, transportation cost data, and price and manufacturing cost data. These point to the need for a coherent data collection strategy to establish more accurate estimates of residual timber values and the independent variables of the study.

A sensitivity analysis indicated that changes in the profit and risk allowance, in product prices and in processing costa had

significant effects on many of the product models. this points to the importance of establishing a reasonable profit and risk allowance and gathering accurate price and cost data.

In general if these models are going to be useful as guide to ongoing valuation decisions, they must be systematically updated and refined. Part III gives specific suggestions for model maintenance.

CHAPTER 1: INTRODUCTION

The Forest Values Program, a component of the Sustainable Forestry Initiative of the Ontario Ministry of Natural Resources, was established to determine fair values for the numerous benefits and commodities produced from the Crown collection in Ontario. This follows recent Ministry of Natural Resources (MNR) policy, as published in Direction '90s. This document states that "Prices charged for resources should reflect a fair return to the public, the extent of benefits received, the need to encourage efficient resource use, and the cost of protection, renewal, restoration, and rehabilitation."

The **Quantification of Residual Timber Values** (QRTV) study was commissioned to achieve two major objectives:

1) To produce rough estimates of the relative value of standing timber for major industrial uses over the past five years.

2) To discover what factors most strongly influence the value of timber standing on the stump; and

This type of study has never been done on a large scale in Ontario and the information generated should be extremely useful. For example, the most obvious use would be to enable MNR staff to compare, albeit roughly, the value estimates of "timber on the stump" using the models developed here with the Crown dues and "in-kind" services provided by timber licensees. However, it is important to stress that this study cannot and does not determine whether the total value of Crown dues collected by the province is "fair". It must also be emphasized that the absolute figures for the Residual Timber Value (RTV) discussed here have little meaning out of context. It is the relative values that are more meaningful.

A second use would be to provide assistance in the setting of regeneration priorities. The sites that produce the highest residual values will be among the most valuable for timber production and should receive more intensive treatments. Note that the costs of silviculture and the estimated future stand attributes also have to be considered.

Also, this project is a first step in valuing all the benefits produced from the forest. If other benefits are valued too, then the relative economic gains and losses of various resource allocations can be evaluated.

The study presented here is a first effort. As later sections of this report indicate, there are many possible refinements that could be made to improve the estimates generated. However, the consultants are confident that the factors which most significantly influence timber values have been identified. The relative timber values estimated here are thought to be accurate on average. However, the "actual" value of any particular stand could differ substantially from the figures indicated in this report.

The outline of the proposal and details of the model design, data collection effort, and subsequent analysis have been carefully examined with the Forest Values Group staff throughout the duration of this work at regular meetings. This has been done to ensure that the client's objectives are fully met.

The report is presented in three parts. Part I deals with northern Ontario, Part II with southern Ontario and Part III is the Users' Manual for assisting those who may want to use the models developed in the other two parts.

Chapter 2 of this Part I describes the economic basis for the methodology used in this study. Using economic theory as a basis, a model has been designed which captures as much theory as possible, but which takes into account the practical limitations of data availability. The structure of the model that seems to best reconcile theory with reality is outlined in Chapter 3. Chapter 4 describes the data collection procedures that were followed, and discusses some of the difficulties that were encountered. Chapter 5 discusses the modelling methodology and describes the model estimation steps that were taken.

The resulting residual value estimates and identification of significant factors affecting residual timber value are reported in Chapter 6. Chapter 7 provides an assessment of the general conclusions arising out of this study.

CHAPTER 2: ECONOMIC UNDERPINNINGS

A striking feature of the market for "timber on the stump" in Ontario is that there are two very distinct economic conditions in the province under which timber is harvested. The first obtains mainly on Crown lands which are located primarily, but not exclusively, in Northern Ontario (which may be roughly defined as the area north of the French River). The other obtains in the remaining central and southern parts of the province which we will call Southern Ontario.

The important characteristic of commercial forestry in Northern Ontario is the lack of a widespread competitive market for standing timber. There are several important reasons for this:

i) The Crown owns a large proportion (85%)[1] of the productive forest collection in Ontario, an overwhelming part of which is in Northern Ontario. Typically, wood using mills are separated by long distances and so there are often very few mills that have an interest in using wood from a given stand. This gives rise to imperfectly competitive market structures, even bilateral monopoly in extreme cases. Economic literature suggests that prices are usually negotiated in these instances.

ii) The Crown in the past sought to stimulate regional development by encouraging the forest industry. This encouragement often took the form of offering standing timber to processing facilities at reduced prices.

iii) By entering into long-term licensing arrangements with major timber users, the province has sought leverage over the harvest and post-harvest actions of the forest industry with the intent of providing sound forest management. These actions have led to negotiated long-term licences and barriers to free entry and exit for the buyers of standing timber.

Because of the dominance of the northern forests, provincial timber pricing policy tends to be overshadowed by the practices there. Thus, Ontario Crown timber dues are set according to base rates, which are adjusted quarterly to reflect changes in

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[1] Forestry Canada. 1989. Selected Forestry Statistics. The province owns 39.72 million ha of the 46.6 million hectares of inventoried forest land in Ontario.

finished product prices. There is no formal mechanism for linking the Crown dues rates to stand location or timber quality. In addition, the Crown dues indexing formulae are based on assumed province-wide final product mixes and, where the actual mix from a mill differs significantly from this average, serious price distortions may be present. Thus, the Crown dues paid on wood cut and used by a kraft pulp mill will be roughly equal to those for roundwood going into a newsprint mill.

Another potentially serious distortion in pricing is caused by uniformity of Crown dues with respect to timber location. Thus, the Crown dues payable on wood growing beside a mill will equal the dues paid on identical wood 150 km from the mill.

In the absence of a competitive market, the administered prices set by MNR do not provide the economic signals which are likely to lead to a socially optimal, or even satisfactory, allocation of resources. When provincially-owned timber is priced too low, the public does not get a fair return and there is a tendency for over-harvesting; the opposite situation leads to under-utilization and wasteful extraction approaches such as high-grading. Furthermore, the administered values are not useful in the evaluation of access and silvicultural investments. This is especially important in light of ever-decreasing funding. Also, administered prices do not necessarily assist investment planning by industry because they do not convey the correct market signals. The absence of a market sensitive price system also makes the province vulnerable to trade actions. Finally, through the sheer volume of Crown timber sold, the price of Crown timber affects the price of timber sold on private lands and if incorrect, affects the allocation of resources there also.

What is the true value of standing timber? Such a question is at the heart of economic theory. In principle, standing timber is worth whatever someone will pay for it. When there is a well-developed market for a good, we witness the obvious truth of this statement. However, the principle continues to be valid even in the absence of markets. It implies that if one were to take the free market value of the goods produced from the timber, such as lumber, pulp, veneer, plywood and waferboard, and subtract the free market costs of harvesting the timber, transporting it to the mill, manufacturing the resulting products, and making an acceptable profit, the remaining value is the maximum amount that a buyer, who intends to use this timber for producing one of the goods discussed, would be willing to pay for the standing timber. The value of Crown timber calculated as if there were a market for it can thus be obtained as a **residual value.**

In essence, the residual value calculation makes use of the fact that the demand for stumpage is derived from the demand for **intermediate or final** wood-based products such as pulp,

intermediate or final wood-based products such as pulp, newsprint, and lumber which are nearest to "timber on the stump", in its successive transformation on the way to eventual conversion into **final** capital or consumption goods (such as newspapers, housing, furniture) and which are also bought and sold in relatively competitive markets. Therefore, the Residual Timber Value (RTV) is sensitive to market conditions. Thus, if the costs of production rise while prices of the intermediate and final products remain the same, then the value of timber on the stump becomes less. If product prices fall and costs remain the same, the timber value also falls.

The residual value technique attempts to apportion the final value of timber between the timber owner and the factors of production. An allowance for risk and profit earned by the harvesters, transporters, and mill owners is included in the costs. This profit and risk allowance is usually of the order of 15-20% of the production cost. The basis for assuming that the residual part of timber value accrues to the timber owner is the assumption that the factors of production such as labour and capital earn returns that are determined by the market. This assumption is tied to the further assumption that there is a large amount of capital and labour available. If a capital owner tried to charge more than the market price for capital, there would be another potential vendor who would settle for the market price. In theory, this competitive mechanism effectively creates market prices that prevent supra-normal returns to capital and labour.

In practice, these assumptions do not hold to the extent envisaged in economic theory, especially in smaller towns where factors of production might be limited. In effect, the setting of the profit and risk allowance becomes a policy decision.

CHAPTER 3: DESIGN OF THE CONCEPTUAL MODELS

The model calculates Residual Timber Values (RTV) in relation to a number of **demand side variables**, such as price trends and business cycle effects, and **supply side variables**, such as stand characteristics, for given products and then uses regression analysis to determine which independent variables were more important in predicting the value of the dependent variable, i.e., the RTV, in sampled forest stands in Ontario.

Regression analysis is normally used to uncover quantitative relationships between a dependent variable and a number of independent variables that could possibly affect the former. The usual assumption is that the independent variables are measured independently of the dependent variables. In this project regression analysis is used somewhat differently. As will be seen below, the measurement of the independent variables is not separate from the measurement of the dependent variable. The Residual Timber Value (RTV) which is the dependent variable has been obtained from the same factors that have been used for calculating the logging and transportation costs and so there is an inherent relationship between the two through the method of calculation. There can, thus, be no uncovering of new relationships between the dependent and the independent variables by using regression analysis. What can however be done is to find which of the independent variables are <u>more</u> important in determining the residual timber value as calculated for the stands for which data were obtained. This can give us a direct relationship between the RTV and independent market, stand and mill variables; and that is what has been done.

There are three critical assumptions that underlie the approach taken in the Northern Model. These are:

(i) That all of the residual value is attributable to timber and not to any of the other factors of production. This implies the acceptance of a constant profit and risk rate. If the normally acceptable profit and risk rate in the industry is more than that used in the model, the model will tend to overestimate the residual wood value;

(ii) That the opportunity cost of not employing the labour, capital, and other inputs is equal to zero. That is, should the mill close, the labour and capital could seek other employment and earn equal returns; and

(iii) As a corollary to (i) and (ii), that the residual value of timber will become zero should the mill close. If not, at least part of the residual value should be ascribed to other factors of production.

Quantification of Residual Timber Values

The identity for the residual timber value is:

(1) RTV = P - processing costs

where RTV = residual timber value
P = finished product price

and processing costs include the costs of mill processing as well as the costs of harvesting and transporting timber to the mill. It is important to ensure that there is consistency among the units of the variables. RTV is expressed in dollars per cubic metre (gross merchantable roundwood volume basis), which necessitates the use of a set of factors to convert units of finished product to equivalent quantity of roundwood. Equation (1) which is also known as the Rothery approach to determine residual timber value can be expanded if the cost term is elaborated:

(2) $RTV = P - (1 + PR) * (MC + T + H)$

PR = profit and risk allowance
MC = manufacturing cost
T = cost of transport from landing to mill
H = harvesting cost

The sum of (1 + PR)*T, (1 + PR)*H, and RTV equals the hypothetical open-market value of wood delivered to the millgate. Note too that the variable MC includes the costs of mill labour, capital, energy, and land (the mill site).

The values of MC, T, and H depend entirely upon the characteristics of the stand and the processing plant which accepts the timber. The value of P depends largely on the market and to some extent on stand characteristics that determine quality of the product. However, to make the calculation implied by Equation (2) whenever a stand of Crown timber is harvested would require a prodigious effort. Therefore, this project computed the value of RTV, the residual timber value, for a representative sample of mature, commercial stands over much of Ontario and then used the regression analysis technique to estimate the relationship of key market, stand and mill characteristics to RTV. In this way, the price and cost information is embedded in the estimated parameters of the regression equations.

Average Product Prices and Mill Processing Costs have been estimated from published reports and separate regressions were run for five main classes of forest products. In the Northern Model, these are:

i) Spruce-Pine-Fir (SPF) Lumber 2x4's (f.o.b. mill)

ii) Northern Bleached Softwood Kraft (NBSK) Pulp (delivered to U.S.)
iii) Groundwood Pulp (delivered to U.S.)
iv) Veneer & Plywood (delivered to U.S.)
v) OSB/Waferboard (delivered to Toronto)

Average transportation costs per kilometre for highway and non-highway distances were also established as were costs of representative harvesting systems. The result is that the model may be used to estimate the residual timber value of a stand using only stand description data and distance from the relevant mill. The need to collect detailed cost information is eliminated.

The residual value of timber in dollars per cubic metre of round wood has been regressed on a number of independent variables as depicted in Equation (3) below:

(3) Residual Value = f(MNR District, Species, Site Class, Stand Height, Age at Harvest, Tree Size, Trees per Hectare, Volume per Hectare, Harvesting System, Season of Harvesting, Roughness of the Ground, Amount of Underbrush, Slope, Branchiness, Whether Harvesting Equipment had Cab Levelling Capability, Number of Categories into which Logs had to be Sorted, Logging Labour Unionised or Not, Highway Distance to Mill, Non-highway Distance to Mill)

The above list of independent variables was intended to include as much of the information that industrial managers use in their decision-making as possible. These variables were viewed as having the most potential to significantly affect the residual values. However, as the analysis proceeded, many of these variables were found to have effects that were small and/or statistically insignificant and were dropped from the final model. (The final list of variables is discussed in Chapter 5.)

As will be clear from the data collection discussion (Chapter 4) the prices of groundwood pulp and veneer & plywood were difficult to obtain and are less reliable than other prices. These results should therefore be treated with caution. In addition data for veneer & plywood and OSB/Waferboard are too few and, therefore, unsuitable for drawing general inferences.

The MNR Districts were entered as "Dummy" variables.

The regression equations were used to estimate the residual value

of the species used in the five production processes. The user must ensure that the appropriate species are used for each production process so that meaningful figures are obtained. Thus, for example, the equations could be used to calculate a residual value for poplar used to produce SPF lumber. The figure, however, would be meaningless because we know that poplar trees cannot produce SPF lumber.

The species associated with each of the five production processes are shown in Table 1:

Table 1
Products and Species

Product	Species
SPF Lumber	Spruces, Jack and Red Pine, Balsam Fir
NBSK Pulp	All species
Groundwood Pulp	Spruce, balsam Fir
Veneer & plywood	White Spruce & All Hardwoods
OSB/Waferboard	Poplar

Site class describes the quality of the growing site with respect to the predominant species. Site quality and stand height are the two variables which are thought to best represent "quality" of a stand. Age at harvest is also a stand characteristic that may affect the quality and value of standing wood. Tree size (or piece size) which is the estimated average volume per tree in a stand, including all species, also affects logging costs. Tree size is likely to be related to age, species, and site. It was derived by taking the number of trees and gross merchantable volume per hectare from Plonski's Yield Tables (Plonksi, 1974)[2]. Volume of timber per hectare is widely considered to be an important stand characteristic affecting logging costs and hence value of standing timber (Jackson and McQuillan, 1979)[3].

The harvesting system, season of harvesting, roughness of the

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[2] Plonski. W. L. 1974. Normal Yield Tables (Metric) for Major Forest Species of Ontario. Ministry of Natural Resources, Queen's Park, Toronto. 40 pp.

[3] Jackson, David H. and Alan G. McQuillan. 1979. A Technique for Estimating Timber Value Based on Tree Size, Management Variables, and Market Conditions. For. Sci. 25(4):620-626.

ground, amount of underbrush, slope, branchiness, whether harvesting equipment had cab levelling capability, number of categories into which logs had to be sorted, and whether logging labour was unionised or not are all factors that affect logging costs. These were included in the regressions since they also affected residual timber values, although each one separately turned out to be of limited significance.

Distance to mill was taken from scaling records and initially divided into two variables: highway distance to mill and non-highway distance to mill. The latter variable referred to the distance from stand to the highway (or mill if no highway transport is required) and the former referred to distance transported along provincial highways to the destination mill. The use of two variables was thought to be useful because off-highway transport can be slower and more expensive than highway hauling, and both variables are easy to measure. In later runs both distances were combined to test the overall distance effect.

The data from which the results of this study are obtained clearly pertain to areas that are currently accessible. Using the regression equations developed here to estimate the possible residual timber values in currently inaccessible areas requires a clear understanding of who is to bear the cost of road construction. If the Province is to bear the cost, and there are many reasons for it doing so, then the equations developed here can be used with a fair degree of confidence. However, if the forest industry is to bear all or part of this cost then the residual value obtained from this report will have to be appropriately amended. The consultants did not further address this question. All that may be said is that since roads usually benefit other forest users and facilitate regeneration activities and subsequent silvicultural treatment and surveys, only a portion of the road building cost should be charged against extracting the timber.

CHAPTER 4: DATA COLLECTION

The application of the Rothery approach requires data concerning product prices, mill manufacturing costs, and the characteristics of the wood and area of harvest.

Field Data Procurement

Six sub-contractors were engaged to gather information concerning harvested timber, harvest areas and destination mills from the field offices of 21 MNR administrative districts. The sub-contractors were grouped into three teams; each team needed one week to sample within a district.

Though the process of data collection employed here cannot be called "random," the consultants believe that the data are indeed representative of the current situation in Ontario. All districts in the boreal forest zone, except Moosonee, were visited. The districts of Sault Ste. Marie, Sudbury, and North Bay, located in the transition zone between the boreal and Great Lakes forest type, were also sampled. In the Great Lakes forest zone, data were collected from Algonquin Park, Midhurst, Cambridge, and Kemptville districts. A complete schedule of field data collection sites is given in Table 2 below.

All sampled districts did not provide the same amount of data. In some places it was easy to get meaningful information, in others almost impossible; and this gives a certain bias to the data set.

Standardized data forms were designed to ensure that complete records were obtained. Copies of these forms have been placed in Appendix 1. Forms 1 and 2 were used for this Model. Form 1 was designed to collect stand description information from Crown land managed under Order-in-Council (OIC) licences, Forest Management Agreements (FMAs), and District Cutting Licences (DCLs) in the boreal and Great Lakes forest zones. Form 2 described the harvest systems used, operating conditions, and destination mills.

Table 2
Schedule of Districts Sampled (1992)

Week Starting	Team 1	Team 2	Team 3
July 13	Timmins	Wawa	Hearst
July 20	Kirkland Lake	Chapleau	Cochrane
July 27	Nipigon	Red Lake	Sault. Ste. Marie
August 3	Kenora	Geraldton	Sudbury
August 10	Thunder Bay	Dryden	North Bay
August 17	Fort Frances	Sioux Lookout	Kemptville
August 24			Algonquin Park

The major species sampled were black and white spruce, jack pine, balsam fir, and poplar. Black and white spruce were often grouped together while larch and cedar were often classed as "other conifers".

The stand data collected included stand location information, FRI working group, species composition, site class, height, and age. This information usually came from depletion ledgers, although sometimes the cutting approvals were used to determine the planned harvest area and post-cut maps or aerial photos used to verify the actual harvest.

An attempt was made to collect three volumes per stand: Plonski volume, cruise volume, and scaled volume. The Plonski volume was obtained by assuming that each species grew in the same manner as if it were the dominant species in the stand, and then adjusting the volume per hectare given in Plonski's Yield Tables by the stand species composition and stocking. This volume was recognised to be the least reliable volume because Plonski's tables are not always accurate in all parts of the province and because the FRI inventories were sometimes out of date by almost thirty years, although the average appeared to be 12-15 years out of date. Though not always reliable, this volume was obtainable for each stand.

Cruise volumes and scaled volumes are often within five or ten percent of the true harvest volume, according to most knowledgeable observers. However, these were only available in a few cases. Timber was scaled on the basis of cutting approvals,

which covered anywhere from a dozen stands to well over one hundred stands. Most frequently, there were at least twenty stands per cutting approval. Similarly, cruised volumes often pertained to cruise lines or areas. Therefore, these volumes had to be pro-rated by stand. Pro-rating was based on the reduced area approach, in which the harvest area is adjusted to an equivalent fully stocked area.

It turned out that there was insufficient scaling and cruising data to run the regression models. As a result, the models have been based exclusively on data from Plonski's Tables. This needs to be kept in mind when any possible use of the model is considered.

The final data collected pertained to tree size (piece size), which was recorded in units of cubic metres per tree. This figure was calculated in one of two ways. Where scaling reports listed the number of stems tallied per species, the volume per stem was obtained. In other cases, the number of trees per hectare was taken from Plonski's Tables, then adjusted for species composition, stocking, and harvest area, and divided into the total species volume (taken from Plonski or taken from scaling or operational cruise records). Because of the inconsistent availability of cruised and scaling volume records, it was the latter method that was finally employed.

The data collection crews also completed a harvesting data form for each cutting approval area (Form 2 in Appendix 1). The information recorded on this sheet was usually obtained from the local unit forester and/or forest technician. Sometimes the mill destination was evident (e.g., on some FMAs, almost all wood of certain species went to the licensee's mill) and other times it was obtained from the scaling records. Data collected using this form consisted of the harvesting system used, the season of operation, whether the harvest was a clearcut and whether it was performed by unionised workers.

Harvesting costs were calculated using relationships developed by FERIC (Mellgren, 1990)[4]. Costs were obtained for six different harvesting systems. The relationships that were developed were suitably complex, and adjustment factors were used that were based on ground roughness and slope, the degree of underbrush, branchiness, and number of sorting categories at the landing. The detailed quantification of these variables is described in Mellgren (1990). Owing to the unavailability of these data in a

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[4] Mellgren, P.M. 1990. Predicting the Performance of Harvesting Systems in Different Operating Conditions. Special Report SR-67. Forest Engineering and Research Institute of Canada, Pointe Claire, P.Q. 22 pp.

form compatible with the FERIC system, data collectors simply asked the local forester or technician for qualitative estimates of these data.

The final component of the data set was the destination of the wood. The two most likely destination mills were identified and the highway and non-highway distance to each mill recorded. Space was provided in case delivered wood costs were available.

There was a great deal of variability in record keeping approaches among the different districts and management units. The paper trail that exists in many districts is as follows:

1) Cutting approvals are signed each year by MNR staff. These identify areas in which harvesting in the current year is allowed. There are often FRI maps which are used to show the proposed area. The area covered under one cutting approval constitutes a cutting block for administrative purposes.

2) The approved area may or may not be cruised in order to make a more accurate estimate of the available volume. On FMAs, the company does the cruise and usually retains the data. On Crown Management Units, the Crown will do the cruise and keep the data. However, it appears as though cruising has not recently been done on most CMUs because of tight budgets.

3) All or part of an approved area may be cut (or none of it, which is rare). A record of the area harvested is made, often in the form of an FRI map. At some point, the actual harvest area will be calculated but the area of each stand that is cut is only sometimes recorded.

4) The timber which has been cut is scaled by weight or by volume and the results reported in terms of volume by species. The scaling returns are recorded on the basis of cutting approval number.

In these cases, the key determinant of data quality (assuming a correct FRI) is the area covered by a cutting approval. The size of the cutting approval determines the number of FRI stands which are aggregated and therefore determines the number of data points dependent on a single set of scaled volume data points. Some managers took the approach of keeping the cutting approvals small, which increased the amount of paperwork for the forester but provided a larger degree of control, as well as more useful harvest data. Other managers went to the other extreme and issued one cutting approval for an entire management unit, covering hundreds of stands. For the purposes of this study, there was no point in gathering records in such circumstances. This situation often occurred on FMAs, hence much of the data collected came

from Crown Management Units (CMUs).

In some other districts, cutting approvals were not used to find the harvest area. For example, in one district, records in the Silvicultural Information System (SIS) were up-to-date and showed the harvest area by stand and licensee. The scaled volumes were found in the cutting approval summary and checked against the composition of the stands in the approval area. Sometimes, there was a poor match and no reconciliation was possible. In this district, extensive cross-checking was done because the FRI photography was out of date by thirty years, the FRI maps had been updated to 1980 and the computer database updated to 1990. Thus, there was great potential for mis-matches. The following cross-checks were made:

i) The FRI code for cut stands was checked in the database and compared to the SIS record.
ii) Maps of cut-over areas were used to verify the harvest area by stand.

In some places, depletion ledgers showing areas and volumes cut by FRI stand were kept up until 1985-86. It is unfortunate that these were not continued into the study period, since they would have been extremely useful.

Price and Cost Data Procurement

Further data were needed to establish the dependent variable of the analysis - the Residual Timber Values (RTV). These data fell into two groups: price data and cost data. The complete set of price and cost data and sample calculations are given in Appendices 2 and 3.

Prices

1. SPF lumber prices were obtained from a pair of reports produced for the Ontario Ministry of Industry, Trade, & Technology (Trusty, 1989, 1991)[5] and Random Lengths. However, we used the Trusty data because Trusty provided f.o.b. prices

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[5] Trusty, Wayne. B. and Associates Ltd. 1989. Ontario's Spruce, Pine, Fir (SPF) Sawmill Industry: An Economic Analysis. Prepared for The Industrial Restructuring Commissioner, Ontario Ministry of Industry, Trade, and Technology. 124 pp. + App.

Trusty, Wayne. B. and Associates Ltd. 1991. Ontario's Spruce, Pine, Fir (SPF) Sawmill Industry: An Economic Update. Prepared for The Special Advisor on Economic Adjustment, Ontario Ministry of Industry, Trade, and Technology. 43 pp. + App.

specific to Ontario while Random Lengths gave prices delivered to Toronto from no specified point of origin (the use of which would necessitate assumptions about transport costs from the mill). The Random Lengths data were later used, however, to establish the business cycle.

2. The Eastern Canadian prices of NBSK pulp were obtained from the Price Waterhouse report titled "The Market Pulp Industry 1986-1990" prepared in October 1991 for the Forest Sector Advisory Council. The prices given on page 29 of that report are delivered prices to the American market, for which transportation costs are also provided on page 16. The model uses the price of the product at the mill, calculated as the difference of the above figures.

3. The current price (October 1992) of groundwood pulp was obtained from an industrial source. This was compared with the current price of NBSK pulp as provided by the same source. Groundwood pulp prices for previous years were then estimated by applying the 1992 ratio of groundwood pulp:NBSK pulp prices to the NBSK prices described above.

4. Prices for softwood and hardwood veneer & plywood were derived from value and volume of shipment data provided by Statistics Canada in Table 27 of Catalogue 25-202, then updated through the construction of an index. (See Appendix 2.)

5. OSB/Waferboard prices were obtained from Random Lengths 1991 Yearbook. The prices used were for OSB/Waferboard delivered to Toronto. A transportation distance of 800 km was assumed and a rail transportation cost of 2.2 cents per MSF (3/8" basis) per km applied to derive a cost of transport from mill to Toronto. The estimate for rail transportation cost was taken from a 1989 report by CPM Consultants Inc. titled "Wood Panel Industry Review" prepared for the Industrial Restructuring Commissioner, Ontario Ministry of Industry Trade and Technology. These data were also updated through indexing. (Appendix 2)

Processing Costs

Published operating and capital costs were available for lumber, and logging. Operating and capital costs for veneer & plywood were derived from Statistics Canada. The treatment of capital expenditures is notoriously complex. Where published data were unavailable, estimates were made. Capital costs were derived from Statistics Canada data for the pulp products used in this project. Estimates for OSB/ waferboard were made on the assumption that capital costs here bear the same proportion to total costs as in the lumber industry.

1. Total (capital and operating) production cost data for the

Ontario lumber industry in 1987, 1988 and 1990 were taken from the two Trusty reports (1989, 1991). In 1988, fixed costs made up approximately 11-12% of total costs. Data for 1986 and 1989 were estimated by constructing an index of production costs for the lumber industry from Statistics Canada as described in Appendix 2. Production data from the table titled "Production of Softwood and Hardwood Lumber by Province" and processing cost data from the table titled "Principal Statistics - Sawmill and Planing Mill Products Industry" given in Catalogue 25-202 were combined to derive the processing cost per unit of lumber produced.

2. Operating cost data for pulp and paper were obtained from the Price Waterhouse report titled "The Market Pulp Industry 1986-1990" prepared in October 1991 for the Forest Sector Advisory Council. The processing costs were given on page 16 and do not include capital costs.

An attempt was made to estimate capital costs as a percentage of total production costs for the pulp groups. However, this exercise was frustrated by the fact that Statistics Canada combines data for all the paper and paperboard manufacturing groups. Ultimately it was decided to use the results of a recent study of the Ontario pulp and paper industry by Forestry Canada (Forestry Canada, 1992).[6] This study yields an average capital cost share of 15.2% for the industry over the period 1964-1988. For the purposes of this report capital costs were taken to be 15% of the total processing costs for the pulp groups.

3. The current cost (October 1992) of groundwood pulp was obtained from the industrial source mentioned above. This was compared with the cost of producing NBSK pulp as provided by the same source. Groundwood costs for previous years were estimated by applying the 1992 ratio of groundwood pulp: NBSK pulp costs to the NBSK costs described above. Capital costs were derived as explained above.

4. The total processing (operating + capital) costs for plywood & veneer were obtained for 1988 from Statistics Canada, in Tables 24, 25, & 26 of Catalogue 25-202. These costs are an average for the hardwood and softwood veneer and plywood industries, as separate figures are unavailable. For the other years, a cost index was constructed as an average of lumber and pulp processing cost indices (see Appendix 2).

5. 1987 OSB/Waferboard costs were derived from a 1989 report by CPM Consultants Inc. titled "Woodpanel Industry Review" prepared

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[6] Forestry Canada. 1992.. Untitled draft report concerning the Ontario pulp and paper industry, courtesy of D. Booth. Economics Branch, Ottawa.

for the Industrial Restructuring Commissioner, Ontario Ministry of Industry, Trade & Technology. The index used for the Veneer and Plywood Industry (see Appendix 2) was used here to adjust the costs for other years.

From the CPM Consultants Inc. report noted above the 1987 cost of establishing a mill of less than 250 million square feet capacity per annum was taken to be $46 million. The cost for a bigger mill was given as $55 million. For convenience an average figure of $50 million was adopted. If the life of the mill is taken to be 20 years and the appropriate cost of financing is 6%, the annual equivalent capital cost turns out to be $19.70 per cubic metre of roundwood used per annum. This is about 14% of the total (operating plus capital) cost of processing. If the cost of financing is taken to be 10% then the capital costs become about 20% of total processing costs. For this project in the face of the difficulty in obtaining data the figure of 20% was adopted.

Not all the processing cost data are equally reliable. There is reason to place the most confidence in the lumber, pulp, and OSB/waferboard data because they are based on recent confidential surveys. However, it must be noted that the estimates for veneer and plywood processing costs are extremely crude. The variations in quality which are so important for this industry could not be taken into account. A study currently under way at Industry Science and Technology Canada will provide more accurate and refined data. The weakness of the groundwood pulp data which rely on one individual's estimates are also obvious.

Logging and Transportation Costs

Harvesting cost data were obtained from a 1990 FERIC report written by P.M. Mellgren cited earlier. This report provides baseline harvesting cost relationships and factors that can be used to calculate departures from them depending on terrain and stand factors such as roughness, slope, number of trees per hectare, branchiness, and tree size. These costs include capital costs as is clear from Mellgren.[7]

Only 1987 costs were reported. Costs for other years were obtained by constructing an index of logging costs from data provided in Statistics Canada Catalogue 25-201 tables titled "Estimates of Forest Production by Products and by Provinces - Logging Industry" and "Summary of Inputs Used in Manufacturing Activity - Logging Industry". The index is given in Appendix 2.

Because Statistics Canada data had only been published to 1989, the index was calculated as the cost of inputs minus cost of raw

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[7] Mellgren, 1990. pp. 5 & 6.

material divided by total production in years 1986-89. For 1990 and 1991 the index was calculated as a moving average of the increase in logging index values for the previous three years.

The cost of transportation was calculated as the product of distance to the mill and haul cost per cubic metre per kilometre. The highway and non-highway distances were measured on maps by the field data collecting teams. The 1988 haul cost was obtained as an average of two figures provided by Trusty (1989). A separate index for transportation costs was constructed (see Appendix 2) from data in Table 2 of Statistics Canada Catalogue 62-001.

Calculation of Residual Timber Values

From the prices, processing costs, logging costs and transportation costs the Residual Timber Value in each stand was calculated for each of the species that are used in the production of the five products recognised. Sample calculations for the costs and the Residual Timber Value are given in Appendix 3.

The results of these calculations are discussed in Chapter 6 and compared with results of some recent studies as presented in Appendix 4.

CHAPTER 5: MODEL ESTIMATION AND VALIDATION

The purpose of building regression models is to develop simple equations which capture reasonably accurately the relationship between important independent variables and the dependent variable. In this project the multiple linear regression technique has been used because it is not only simple and direct but also permits incorporation of nonlinear relationships by constructing new independent variables by appropriate transformations. Such transformations may be multiplication of two or more independent variables, squaring one or more of them, trigonometric functions, etc.

Estimation

Ordinary least squares (OLS) procedures were used to estimate Equation (3). The statistical package SPSS was employed for both the models. Some basic features of SPSS which were mostly used are given below.

A multiple regression equation can be run by specifying the dependent variable, independent variables, and the method of selecting independent variables for inclusion in the regression equation. In SPSS, five methods were available for selection of variables. The most suitable of these was STEPWISE.

In this method, the first variable considered for entry into the equation is the one with the largest positive or negative correlation with the dependent variable. Next, an F-test is performed to evaluate whether this relationship is significantly different from zero. The variable is included in the equation if the probability of having chosen it wrongly is less than 5 percent ($P < 0.05$) and the F-statistic exceeds a threshold of significance. The process is then repeated, each time using the next most significant variable, until no un-included variables meet the significance requirements.

When more than one variable has been brought into the equation (in the manner just described), the variables are tested in relationship to each other. A new series of statistical tests gauges whether each variable performs an important role as part of the whole. A variable is removed if it fails to meet a minimum F value or exceeds a maximum probability threshold of 10 percent ($P > 0.10$) for making a wrong inclusion.

One of the potential problems encountered during regression estimation is collinearity, i.e., the "independent" variables being in reality actually partially dependent on each other. This

creates the impression that more variance is being explained by the model than in fact is the case. SPSS has a built in facility to tackle this problem. It uses the "tolerance" of a variable as a measure of collinearity. The tolerance of an independent variable relative to all other independent variables is examined. The tolerance of a variable i is defined as $1-R_i^2$ where R_i is the multiple correlation coefficient when the ith independent variable is predicted from the other independent variables. A relatively high default value of tolerance (TOL = 0.0001) was used to permit flexibility in the first runs. As it turned out, the actual TOL values were usually very high showing little collinearity.

After generation of the equations, SPSS produced a series of graphs that were used to check heteroscedasticity (whether the residuals (differences between the actual and predicted values of the dependent variable) were distributed uniformly around zero) and how the distribution of standardized[8] residuals of the dependent variable compared to a normal distribution. In all cases these were found to be reasonably satisfactory, indicating that the data did not violate the normality conditions required for the proper performance of OLS.

The multiple regression estimation resulted in a series of linear equations for the residual values of major commercial species used for five different products in the Northern model and two linear equations for the market values for four species (or species groups) in the Southern model. The equations give us information on what effect a change in the independent variables has on the dependent variable (in the form of the coefficient of the independent variable) and SPSS further generates R^2 statistics which tell us how much variance in the dependent variable is being explained by each independent variable and by the model as a whole. In the formulation of the model from sample data, it was important to look not just at the R^2 which indicates the variance explained in the sample data but also the adjusted R^2 which estimates the variance explained for the entire population. The SPSS package also calculates the standard error. This statistic, used in combination with the T-statistic (a measure related to the degree of freedom in the model), enables one to determine the confidence limits of the coefficients. This means the upper and lower limits that the coefficient might take.

Before beginning the model estimation stage, we randomly selected some 10% of the northern sample data to set aside while the preliminary equations were estimated. These reserved data were later used to test the accuracy of the estimates.

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[8] Standardization involves setting the mean value equal to zero and the standard deviation equal to one.

Quantification of Residual Timber Values

Each model was developed in four stages. First a pre-test was conducted, second a preliminary model was developed, third key variables were identified and a more definitive model developed. Finally, this model was tested against the reserve data. After the model was developed and tested, sensitivity analysis was carried out to determine the effect of different factors internal to the model.

A significant amount of time was spent in the pre-test stage to establish a priori knowledge regarding the behaviour of different independent variables. First, all data were screened to make sure that all data were measured consistently (for example, cubic metres rather than board feet) for all years.

As a second step in pre-testing, the correlation coefficients of all pairs of variables were calculated. These were examined for high correlation among the independent variables, and the direction of the relationship (expressed as a positive or negative sign of the correlation coefficient). Alarmingly large magnitudes of coefficients such as 0.9 or higher were not observed at all. (If they had been, one of the two highly correlated variables would have been eliminated in subsequent regression runs.) There were no major surprises in terms of the direction of relationship among the independent variables.

In the third pre-testing step, the coefficients of correlation between the independent variables and the dependent variable were calculated. Some relationships were found to be in unexpected directions. For example, sometimes tree size was negatively correlated with the Residual Timber Value (RTV) whereas slope was positively correlated. Fortunately, the degree of correlation was weak in these cases (the correlation coefficients were smaller than 0.5). Therefore, no independent variables were eliminated at this stage and, thus, no bias was introduced.

To develop the preliminary model, a multiple regression was run using the stepwise method. First, a trial model was developed for each product, i.e., for lumber, kraft pulp, groundwood pulp, veneer & plywood, and waferboard, for each year. On the basis of field data and available price and cost data the trial models for different products were run for the years indicated in Table 3 below.

At this point some trials were made to check the sign of coefficients in the regression equations. It was found that those variables which had given unexpected signs of correlation with residual value in the pre-test now had the expected signs in most cases. (This is not an unusual occurrence.)

Table 3
Product Groups and Years
Included in Preliminary Models

Product	Year
Lumber	1986 to 1990. For 1991 field data were available but price and cost data were not.
Kraft Pulp	All years (1986 to 1991)
Groundwood Pulp	All years (1986 to 1991)
Veneer & Plywood	1988, 1989 and 1990. (Data sets for 1986 and 1987 were too small to be used and for 1991 no data were available.)
OSB/Waferboard	1988 and 1990. (Data were unavailable for other years.)

As noted above the stepwise process picks up the more important variables (those that meet the significance and tolerance tests) and eliminates the rest. All the variables picked up in the stepwise regression process are recorded for each product and year in Appendix 5.

In the third stage, the final models were developed. The preliminary models for each product for each year were examined critically. A comparative chart was prepared to indicate the variables selected in each year's model of a particular product. Those variables that were consistently significant and had coefficients with appropriate signs were selected for each product. To test the predictive capability of these selected variables without other variables, they were regressed against the residual value for every year for each product. The outcomes of these runs indicate that the selected variables have very high predictive capability. The adjusted R^2 for the models of lumber, kraft pulp, and groundwood pulp which are based on large data sets, are higher than .75. The values of adjusted R^2 are comparatively low for the veneer and waferboard models, mainly due to smaller data sets. The results of these models are summarized in Appendix 6.

Next an attempt was made to develop a general model for each product based on the total data from all years. At this point, the size of the data files containing all data for all years for lumber, kraft pulp, and groundwood pulp exceeded the capacity of the computer. Therefore, all data points of only the earlier selected variables from each year were combined to form multi-year data sets. For veneer & plywood and OSB/Waferboard all available data were pooled.

Quantification of Residual Timber Values

The models were again run using the STEPWISE method. In some cases, the method did not select all the variables previously selected. This happened because the data for different years had now been pooled. At this point the year as a dummy variable appeared in a number of equations, particularly in the two pulp models. However, the year as a dummy variable was dropped from the models as it has little predictive utility. A summary of the models (for all years' data) based on selected variables for each product are given in Appendix 7.

These models (based on all years' data) were now compared with the year by year product models. This initial attempt to build a model based on the pooling of data from all years did not work well. Specifically for NBSK, groundwood pulp, and veneer & plywood adjusted R^2 values were 0.22997, 0.19814 and 0.16093 respectively. The values of adjusted R^2 for the other two products i.e., lumber, and OSB/Waferboard were somewhat higher being 0.59204, and 0.46022, respectively. This did not justify retaining these models and a more sophisticated approach toward pooling the data for the overall time period was subsequently attempted.

To improve the predictive capability of the models, the price data for all the products were examined critically. It was observed that the low R^2 in the pooled data models were likely due to variation in end product prices during these years. Therefore, an attempt was made to identify a business cycle for each product. Analysis of price data of different products during the period under consideration suggested that the business cycle could be represented either by a single sine (cyclical) curve or by a combination of linear (secular) change and a (cyclical) change along the sum of two sine curves. In the second case, two sine curves with different time periods from peak to peak were combined. The sine curve with the longer cycle was called the major cyclical component; the curve with shorter cycle was called the minor component.

Summing the secular and/or two cyclical components permits the capture of more of the random variation in prices. Thus, in the first model the independent variable was $\text{Sin}(2\pi t/T)$, and in the second model the independent variables were t (representing the secular trend), $\text{Sin}(2\pi t/T)$ (representing the major cyclical component), and $\text{Sin}(2\pi t/(0.5T))$ (representing the minor cyclical component). The value of t in these cyclical expressions depends on the part of the business cycle that each year lies on. The value of T represents the peak to peak length of the major component of the business cycle of the product. The first model was found to be more suitable for the OSB/Waferboard and Plywood & Veneer industries while the second model provided a better fit in the lumber and pulp industries.

The length of the business cycle for each product (T) and the location of each year on the cycle (t) for each product are given in Table 4. Prices of end products for different years, values of $\text{Sin}(2\pi t/T)$, and $\text{Sin}(2\pi t/(0.5T))$ for corresponding years are given in Appendix 8.

The component by component development of the lumber business cycle is shown in Figure 1 and 2. Figure 1 shows the two cyclical components over one complete major cycle, unrelated to any particular year. Figure 2 shows the sum of the two cyclical components (from Figure 1), an arbitrary linear (secular) trend, and the sum of these two.

Figures 3 and 4 show analogous information for the pulp products (kraft and groundwood). For the OSB/Waferboard and Plywood and Veneer industries, no significant secular trend was identifiable from the data available. Thus, Figure 5 shows the business cycle for these products which is just cyclical in nature.

Table 4
Business Cycles and Values of t

Year	Lumber Business Cycle = 6 years	Pulp (Kraft & Groundwood) Business cycle = 10 years	Veneer & Plywood Business cycle = 6 years	OSB/Waferboard Business cycle = 6 years
1986	1.5	9.5	4.0	-
1987	2.5	10.5	5.0	-
1988	3.5	11.5	6.0	0
1989	4.5	12.5	7.0	1
1990	5.5	13.5	8.0	2
1991	-	14.5	-	-

Figure 1.
Major and Minor Components of Lumber Business Cycle

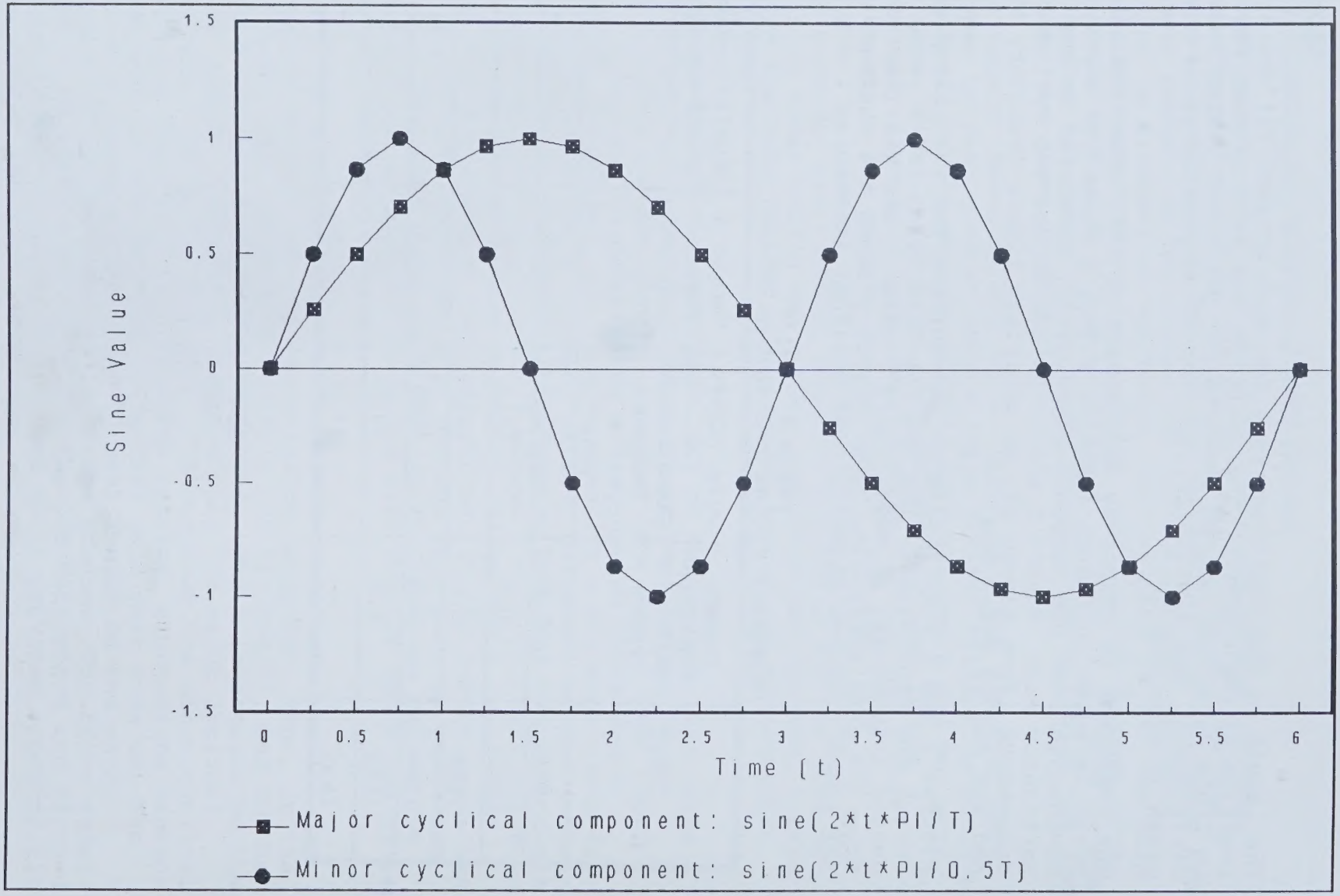


Figure 2.
Secular and Cyclical Components of Lumber Business Cycle

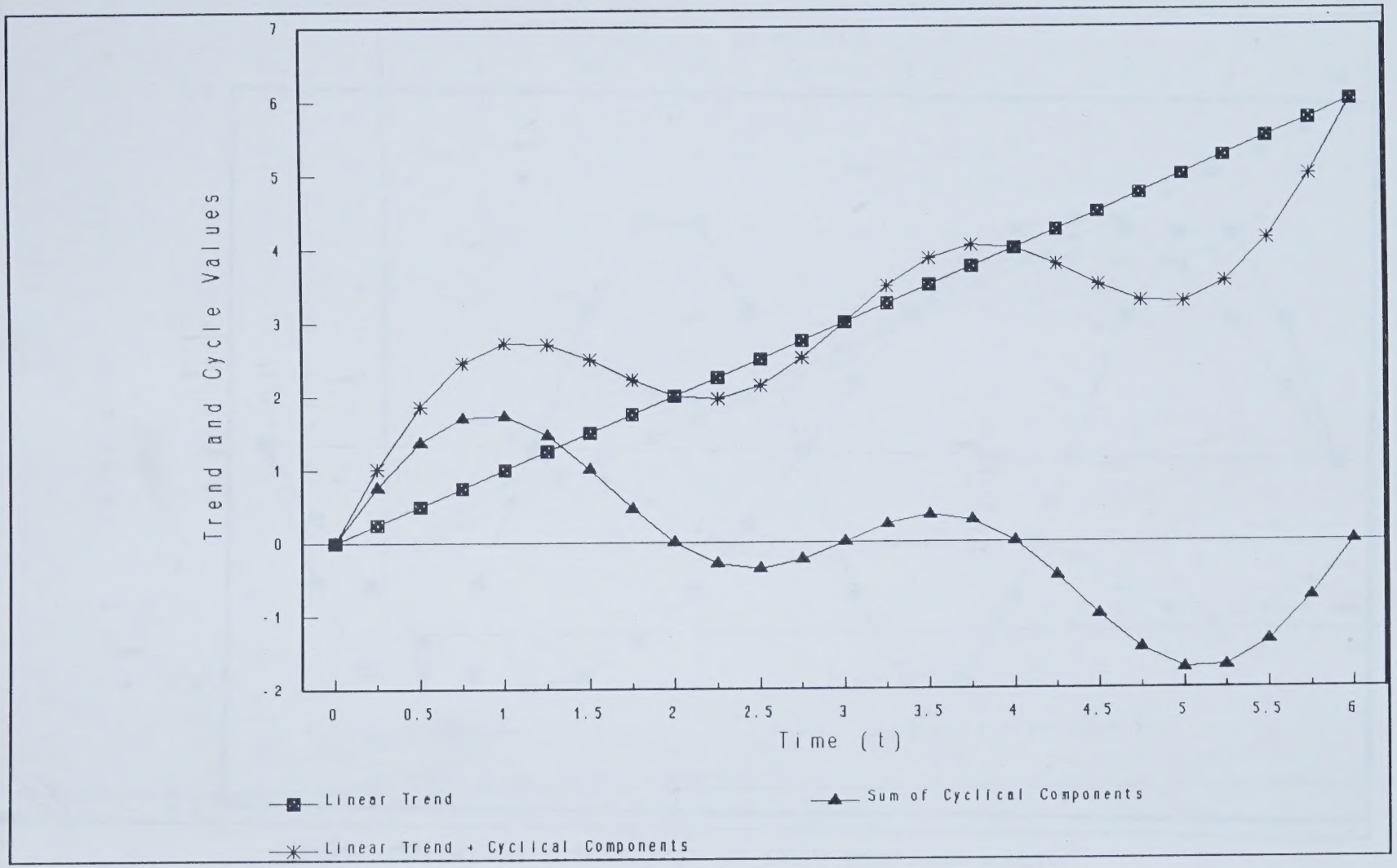


Figure 3.
Major and Minor Components of Pulp Business Cycle

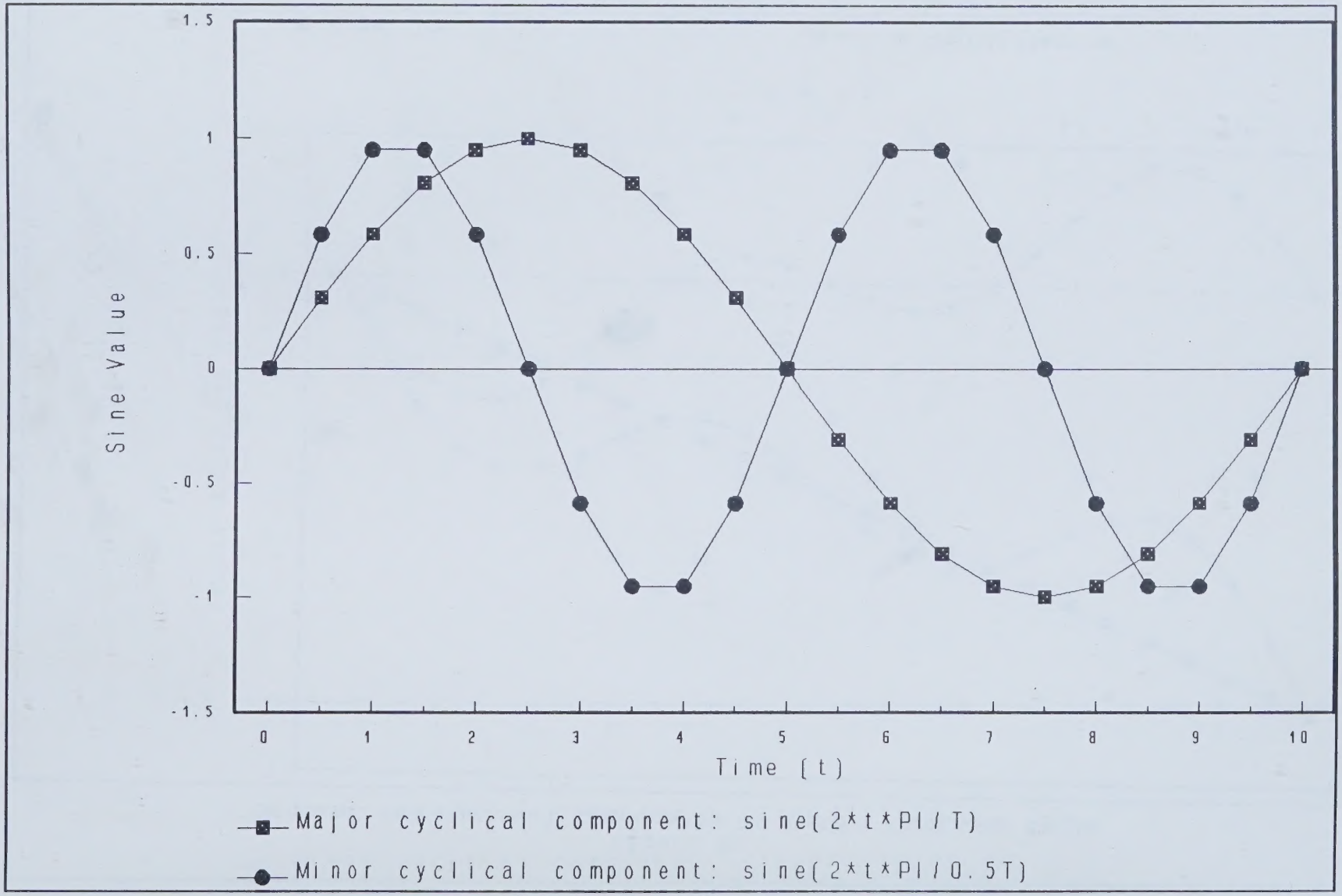


Figure 4.
Secular and Cyclical Components of Pulp Business Cycle

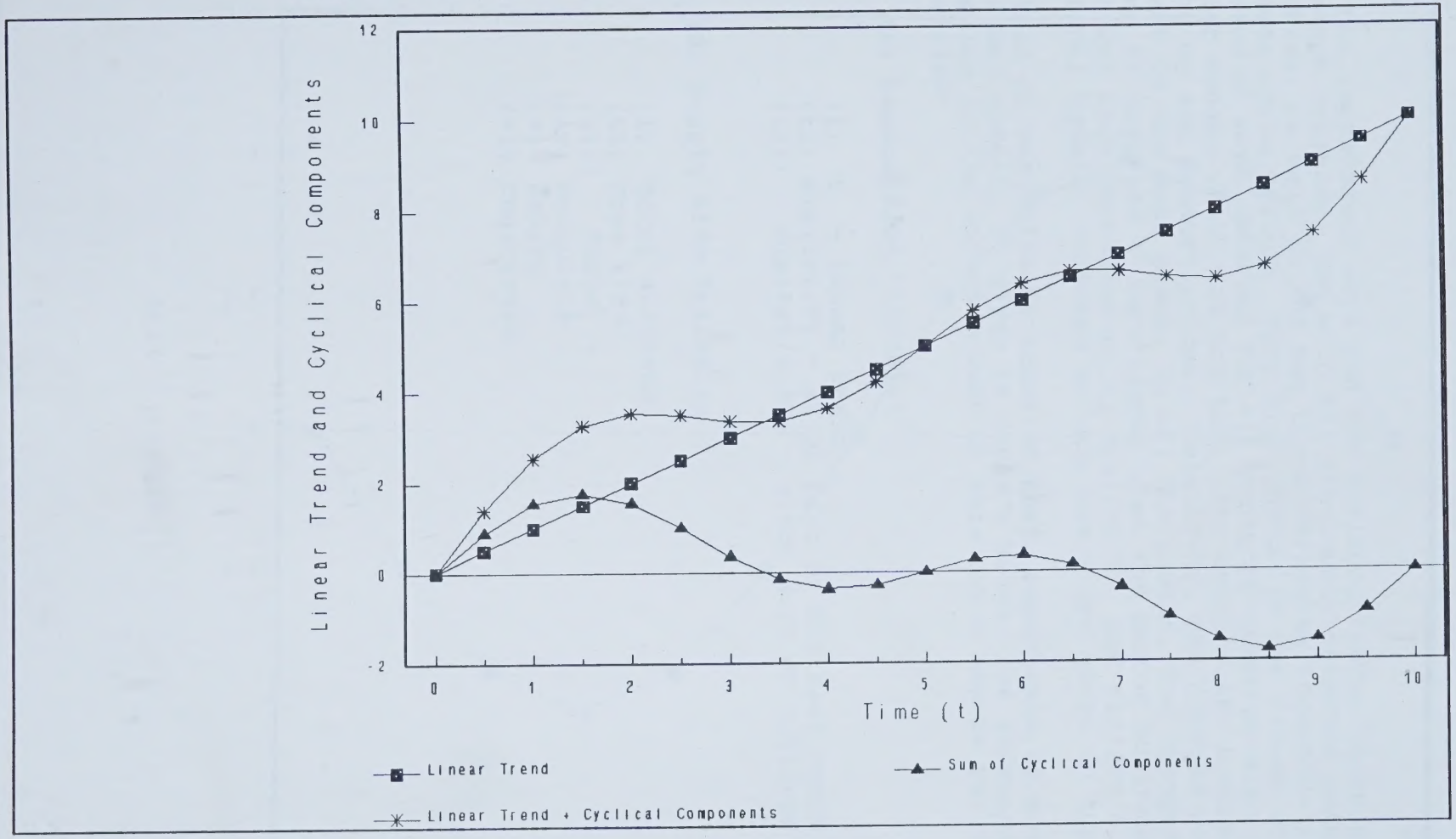
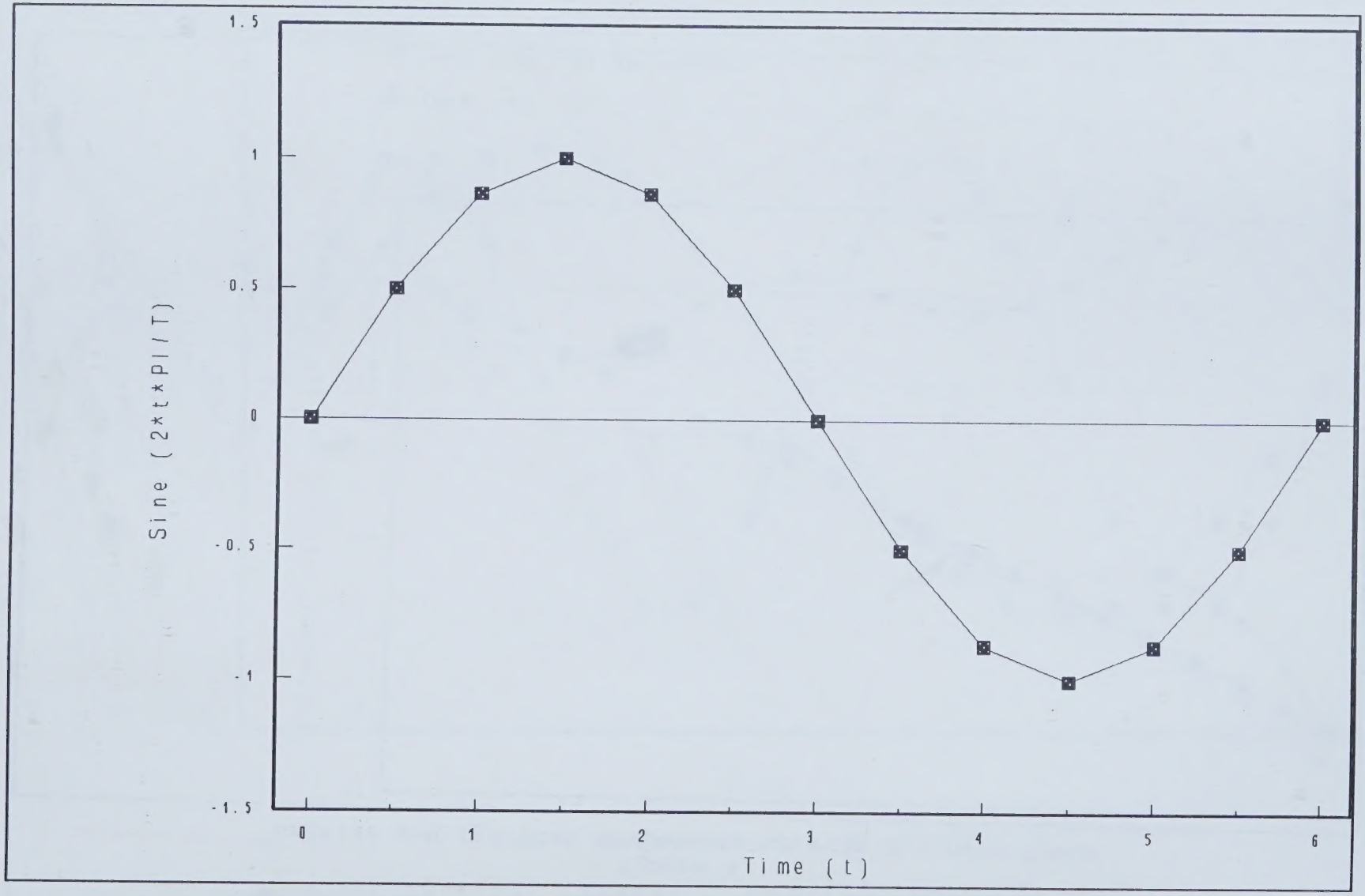


Figure 5.
OSB/Waferboard, Plywood & Veneer Business Cycle



Now, the regressions were run for Residual Timber Value as dependent variable, and with all previously selected independent variables, as well as the new trend variables incorporating the business cycle effects. Very high change in the values of adjusted R^2 were observed for all products compared with the earlier models which did not take into account the business cycle effect on end product prices. Relatively, the changes were highest in the pulp group. In all the models, the changes in values of adjusted R^2 were higher when the second business cycle model was used [modelled by t, $\text{Sin}(2\pi t/T)$, and $\text{Sin}(2\pi t/0.5T)$]. The final models, selected on this basis are given in Appendix 9.

The list of variables in order of their importance,selected for the final models, is given in Table 5 below. The independent variables in the second column of this table may be put in two categories:

(A) Demand Side Variables

(i) t - linear trend
(ii) $\text{Sin}(2\pi t/T)$ - major part of business cycle
(iii) $\text{Sin}(2\pi t/0.5T)$ - minor part of business cycle

(B) Supply Side Variables

(i) Total distance
(ii) Tree size
(iii) Slope
(iv) Roughness
(v) Height
(vi) Underbrush

Table 5
Components of Final Northern Models

Product	Variables
Lumber	(i) Total distance (ii) Tree size (iii) Slope (iv) Linear trend (t) (v) Sin(2πt/T) (vi) Sin(2πt/0.5T)
Kraft Pulp	(i) Total distance (ii) Tree size (iii) Slope (iv) Linear trend (t) (v) Sin(2πt/T) (vi) Sin(2πt/0.5T)
Groundwood Pulp	(i) Total distance (ii) Tree size (iii) Slope (iv) Roughness (v) Linear trend (t) (vi) Sin(2πt/T) (vii) Sin(2πt/0.5T)
Veneer & Plywood	(i) Height (ii) Underbrush (iii) Sin(2πt/T)
OSB/Waferboard	(i) Total distance (ii) Tree size (iii) Sin(2πt/T)

Validation

The process of model validation is an attempt to assure ourselves that we are modelling what we think we are modelling and the results are reasonable.

The Northern Model was validated using two methods. The first method involved checking the goodness of fit and significance of parameters at each stage of model building. As already explained, goodness of fit was evaluated using R and R^2 for sample data and adjusted R^2 for the population. The statistical significance of the relationships was evaluated using the F-test for the overall models and the t-test for individual independent variables. Collinearity was also tested using the TOL statistic.

A second, widely-used test of validity is to use reserved data to check the predicted results against the actual residual values. As noted earlier, approximately 10 percent of the initial data for the Northern Model was reserved at the outset and this was later used to test whether the model would perform similarly using these data. The Northern Model met this final test and the results are shown in Appendix 10 and discussed in Chapter 6.

Sensitivity Analysis

Sensitivity analysis is undertaken to demonstrate the effect on a model's performance of the choices and assumptions made while developing the model. This analysis also gives the user a sense of the overall stability of Residual Timber Values to changes in independent variable values. This will give an indication of how frequently the numbers would have to be recalculated to make the model useful for setting prices (if so desired) in the policy context and will help identify factors that should be carefully measured in further work.

Sensitivity analysis was undertaken by substituting alternative values for key factors and gauging their impact on the Residual Timber Value in the Northern Model. Among these key factors were cost components such as profit and risk allowance and processing costs, the weighting factor for non-highway transport, and product prices. The results are discussed in Chapter 6.

CHAPTER 6: RESULTS

The Residual Timber Value Calculations

As noted above the Northern Model is based on a calculation of Residual Timber Values. In order to perform these calculations an initial choice had to be made as to what profit and risk allowance to use. Based on comparisons with other studies, a base figure of 15 percent was used. (Later in this chapter a sensitivity analysis is examined to determine what effect different levels of profit and risk might have on the results.)

The results of these calculations show that **for the sample used in this study** residual timber values between 1986 and 1991 in northern Ontario range from $\$30.40/m^3$ to negative $\$82.26/m^3$ for species used for lumber production, from $\$89.63/m^3$ to negative $\$38.08$ for species used in kraft pulp production, from $\$172.83/m^3$ to $\$42.91/m^3$ for species used for groundwood pulp production, from $\$566.13/m^3$ to negative $\$28.14/m^3$ for species used in veneer and plywood production, and from $\$57.55/m^3$ to negative $\$60.48/m^3$ for species used in OSB/waferboard production. Table 7 below shows the range of values by product type.

These figures are those encountered in the sample and give only an idea of what the actual range in the province may be. An average obtained from the RTV's calculated in this project would be meaningful only if weighted by actual volumes cut in the appropriate years.

Quirin and Waters (1989)[9] (discussed in more detail in Appendix 4) calculated an average stumpage value of timber used in lumber production in the year 1986 as $7.45 per cubic metre. The range of values encountered in our study for the same product and year is $26.65 to -$36.63 per cubic metre, as pointed out above. There is an erroneous impression created from a comparison of these figures that the two studies do not agree with each other. In reality the two studies address quite different questions and their approaches are so different that no meaningful comparisons can be made. Despite this, it is interesting to note that the Northern lumber model estimates an 1986 RTV of $\$7.45/m^3$ for a conifer stand located 168 km. from a sawmill, with a slope class

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[9] Quirin, G. D. and W. R. Waters. 1989. Timber values, stumpage and the 15 percent export tax: A report prepared for the Industrial Restructuring Commissioner, Ontario Ministry of Industry, Trade and Technology. Mimeo. Toronto, Ontario. 80 pp. + App.

of 1 (slope less than 10%) and an average tree size of 0.25 cubic metres.

In Quebec, Crown charges are set by regions and for the year 1991 the charge for softwoods in Region 13, which borders Ontario, is $\$6.00/m^3$. It does not matter whether the wood is used in lumber production or for pulping. Although it was not possible to calculate RTVs for lumber from actual data for our study, the models permit projections to be made for 1991. Accordingly, the RTV for a stand located at a distance of 100 km. from a mill, with an average tree size of 0.25 m^3 and slope class 1 would be -$\$46.31/m^3$ in lumber production and -$\$2.72/m^3$ in kraft pulp production. If roughly equal amounts of wood go to these two uses then the average RTV **for the stand** would be -$\$24.50/m^3$. For 1990, when the lumber market was a little better and the pulp market was very much better, the estimated RTVs are -$\$13.76/m^3$ and +$\$55.85/m^3$, giving an average of $\$34.80/m^3$. There is a clear difference between the results of this study and the rates charged in Quebec. Most of the difference may be explainable by the fact that 1) the Quebec system may not be as responsive to the market fluctuations as the method used in this study is, 2) the Quebec rates are regional averages whereas those presented here are stand-specific, and 3) two very different approaches have been adopted in the Quebec modelling and this study. In particular, this study calculates RTVs and includes the business cycle. An important point to be noted is that Quebec does not even entertain the idea of a negative stumpage rate. This may be reasonable for the average figures for a region in any year but is a real possibility for an individual stand and, thus, in an economic sense the QRTV model presented here is more discriminatory.

In other cases, our estimated price received for timber on the stump is close to the stumpage rate charged in Quebec. The per cubic metre charge for red pine poles in Quebec in Region 9 is $17.50. The RTVs calculated from the Southern Model of QRTV study are red pine $6.06, oaks $12.75, hard maple $25.66 and ash -$14.44 per cubic metre, in a hypothetical sale lot in southern Ontario, consisting of these species and located at a distance of about 25 km. from a sawmill. Again any comparison must be made with great caution, because the results of this QRTV study go into details of stand characteristics that other studies do not worry about.

TABLE 7
Calculated Residual Timber Values
for
The Northern Model

Product	Year	Maximum RTV $/cu.m. (District)	Minimum RTV $/cu.m. (District)
Lumber	1986	26.65 (Kenora)	-36.63 (Nipigon)
	1987	20.16 (S.Lookout)	-42.87 (Nipigon)
	1988	16.56 (K. Lake)	-33.65 (Nipigon)
	1989	30.40 (Wawa)	-62.65 (Nipigon)
	1990	4.28 (Sudbury)	-82.26 (Nipigon)
	1991	Not available	Not available
Kraft Pulp	1986	39.52 (Kenora)	1.63 (Nipigon)
	1987	57.41 (Kenora)	17.19 (Red Lake)
	1988	76.30 (Kenora)	32.30 (Nipigon)
	1989	89.63 (Kenora)	37.35 (Red Lake)
	1990	70.60 (N. Bay)	17.67 (Nipigon)
	1991	8.18 (Sudbury)	-38.08 (Red Lake)
Groundwood Pulp	1986	108.17 (Kenora)	70.27 (Nipigon)
	1987	130.45 (Kenora)	90.24 (Red Lake)
	1988	154.51 (Kenora)	110.51 (Nipigon)
	1989	172.83 (Kenora)	120.55 (Red Lake)
	1990	156.40 (Kenora)	103.47 (Nipigon)
	1991	88.78 (Sudbury)	42.51 (Red Lake)
Veneer & Plywood	1986	44.80 (Nipigon)	28.14(Nipigon)
	1987	74.63 (Nipigon)	57.04 (T. Bay)
	1988	389.04 (T. Bay)	349.65 (T. Bay)
	1989	566.13 (K. Lake)	536.01 (Nipigon)
	1990	529.77 (K. Lake)	499.94 (Alg. Park)
	1991	Not available	Not available
OSB/Waferboard	1986	Not available	Not available
	1987	Not available	Not available
	1988	57.55 (K. Lake)	41.58 (K. Lake)
	1989	Not available	Not available
	1990	- 10.72 (T. Bay)	- 60.48 (Nipigon)
	1991	Not available	Not available

The Multiple Regression Models

The Northern Model comprises five multiple regression equations constructed to enable analysts to predict the residual timber values from information on key independent variables for each

major product group, in the near future. The Southern Model consists of two equations which predict market value from selected independent variables. In this case two equations are provided to permit choice in the selection of independent variables. Either of these can be used to estimate the sale price of any lot proposed to be put on auction and also to work out the Residual Timber Value on stump of four species groups.

An important point to bear in mind while reading the rest of this chapter is that the results presented are based only on six years (pulp) data at the most. For OSB/Waferboard the data span only two years. Therefore, neither linear nor curvilinear business cycle trends can be expected to hold good for more than a year or two beyond 1991, the last year for which data were available. Nevertheless, the method employed here can be fruitfully used for longer time series data.

The Northern Model

In the trial model, highway and non-highway distance to mill were separate variables. Later on, tests were made to check the explanatory power of total distance as one variable. Total distance as one variable proved to be a better variable (in terms of R^2, adjusted R^2 , and standard error) than two independent variables i.e., highway and non highway distances. Therefore, in the final model the two were combined to make one variable, total distance. Because off-highway travel is more costly, the non-highway distance was weighted by increasing it fifty percent before adding it to the highway distance to get the total. In the models which were based only on stand and mill parameters, distance proved to be a key predictor to Residual Timber Values. Two other variables were also important predictors in different product models. Tree size was strongly related to Residual Timber Values for lumber, kraft pulp, groundwood pulp, and waferboard. Slope of ground was an important predictor of the RTV's for wood going to lumber, kraft pulp, and waferboard. One other variable, underbrush of the ground, came in only in the final models for veneer and plywood.

Tables 8 and 9 summarize these important variables and their coefficients with standard errors in parentheses, for the models without the independent variables corresponding to business cycle of the end products.

Table 8
Summary Showing the Coefficients of Variables and Their Standard Errors for Lumber, Two Pulps, and OSB/Waferboard Models

Product	Adj R^2	Constant	Total distance	Tree size	Slope
Lumber	0.59204	13.93573 (1.2430)	-0.113953 (0.00327)	17.763597 (1.70287)	-4.71500 (0.4190)
Kraft Pulp	0.22997	62.97039 (2.0169)	-0.184506 (0.00666)	25.011227 (2.30138)	-1.38235 (0.6704)
Groundwood Pulp	0.19814	136.3638 (1.6122)	-0.178259 (0.01093)	61.554328 (8.28192)	0
OSB/W'board	0.46022	70.14652 (7.615)	-0.482983 (0.037)	40.372523 (8.104)	-13.3725 (2.053)

Table 9
Summary Showing the Coefficients of Variables and their Standard Errors for Veneer and Plywood Model

Product	Adj R^2	Constant	Total distance	Height	Underbrush
Veneer & Plywood	0.16093	403.77743 (59.2728)	-0.94203 (0.205)	0 0	42.30865 (18.9027)

As stated in Chapter 5, the above results were deemed unsatisfactory and so new models were developed which accounted for the effects of business cycles. In the first trial the business cycle effect was represented by a single variable Sin $(2\pi t/T)$, and in the second trial it was represented by three variables t, Sin $(2\pi t/T)$,and Sin $(2\pi t/0.5T)$). The final values of adjusted R^2 for the above two trials for all products are given in Table 10.

Table 10
Summary of Final Values of Adjusted R2
in
Trial 1 and Trial 2

Product	Trial 1	Trial2
Lumber	0.67981	0.91385
Kraft Pulp	0.65319	0.97575
Groundwood Pulp	0.75209	0.98945
Veneer & Plywood	0.95042	0.95486
OSB/Waferboard	0.99094	0.99094

These results indicate that models in Trial 2 (which includes t, $\text{Sin}(2\pi t/T)$, and $\text{Sin}(2\pi t/.5T)$ as independent variables for variation in prices) produced better fits for lumber, kraft pulp, groundwood pulp, and veneer & plywood. However, the veneer & plywood results proved problematic. The value of adjusted R^2 for veneer & plywood improved only marginally from Trial 1 to Trial 2. Therefore the Trial 1 model was selected as the final model for veneer & plywood. (In both the trials, when the model were run including the total distance as one of the independent variables, the coefficient of distance was positive, meaning the greater the distance of the mill from the stand, the higher will be the Residual Timber Value. This is inconsistent with the theoretical reasoning. Therefore, the final models were run without total distance as one of the independent variables). For the OSB/Waferboard product models, there was no improvement in the value of adjusted R^2 from Trial 1 to Trial 2. Therefore, the simple model of Trial 1, was retained as the final model. For lumber, kraft pulp, and groundwood pulp, the Trial 2 models were selected as final. A summary of final models for all products is given in Tables 11a and 11b which show the coefficients of all variables along with their standard errors in parenthesis.

Table 11a
Summary of Lumber, Pulp, and Waferboard Models

Product	Lumber	Kraft Pulp	Groundwood Pulp	OSB/ Waferboard
Adj R2	0.91385	0.97575	0.98945	0.99094
Constant	59.852212 (1.337741)	206.912954 (1.165925)	276.147621 (1.324969)	53.033785 (1.327598)
Demand Side Variables				
Trend (t)	-13.005201 (0.365974)	-15.980274 (0.093021)	-15.478108 (0.102247)	0
Sin (2π*t/T)	-12.134111 (0.751257)	76.312593 (0.295987)	86.506102 (0.324058)	-82.302972 (1.294911)
Sin (2π*t/0.5T)	-4.276393 (0.439030)	-12.233182 (0.170466)	-14.688989 (0.185591)	0
Supply Side Variables				
Total distance	-0.129276 (0.001538)	-0.114056 (0.001218)	-0.112263 (0.001301)	-0.116856 (0.011417)
Tree size	16.381962 (0.787282)	23.138061 (0.411852)	18.306508 (0.983631)	14.384439 (2.306414)
Slope	-3.026528 (0.195904)	-3.073854 (0.120469)	-2.097216 0.158164)	0
Roughness	0	0	-1.929945 (0.137578)	0
Height	0	0	0	0
Underbrush	0	0	0	0

Table 11b
Summary of Veneer and Plywood Models

Product	Veneer & Plywood
Adj R2	0.95042
Constant	236.590265 (17.830638)
Demand Side Variables	
Linear trend (t)	0
Sin(2π*t/T)	252.478162 (4.906496)
Sin(2π*t/0.5T)	0
Supply Side Variables	
Total distance	0
Tree size	0
Slope	0
Roughness	0
Height	0.813251 (0.389321)
Underbrush	28.990769 (5.074066)

What do these results mean in practical terms? With respect to distance the model is telling us that for every additional kilometre that a cubic metre is transported to reach a mill the residual value of the wood used decreases by approximately 13 cents for lumber, and 11 to 12 cents for the pulp group and waferboard. For every cubic metre increase in tree size there is a corresponding increase in residual value of $16.38 for lumber, $23.13 for kraft pulp, $18.30 for groundwood pulp, and $14.38 for waferboard. As noted in the discussion of data collection in Chapter 4, slope, roughness, and underbrush estimates were based on qualitative assessments by field foresters with reference to five-point classification schemes developed by P. G. Mellgren (1990 and 1980). The model results indicate that for every change in class of slope (i.e., increase in steepness) there is the

following impact on residual values: decrease of $3.02 for wood used for lumber, decrease of $3.07 for wood used for kraft pulp, and decrease of $2.09 for wood used in groundwood pulp. The model of groundwood pulp also indicates that an increase in roughness of ground by one class causes a decrease in residual value by $1.92. Interestingly, an increase in the amount of underbrush is positively correlated with residual value of the wood used for veneer and plywood production. Here the move to a higher underbrush classification brings an $28.99 increase in residual value. This is somewhat unexpected as more underbrush might be expected to increase logging cost and so decrease Residual Timber Values. The reason for this apparent paradox may be in the fact that more underbrush also signifies better sites which might have a significant influence on quality of wood. Alternatively, the result may be an artifact of poor qualitative assessment of underbrush. Crop height is also positively associated with Residual Timber Value in the veneer and plywood model. An increase of one metre in height produces a $0.81 increase in RTV.

Introduction of the business cycle for end product prices permits the model to compute the business cycle effects on Residual Timber Values for the different products. For example, the variations in Residual Timber Values for kraft pulp with time can be represented by the sum of a negative linear trend measured by the coefficient of t, some positive sinusoidal change (with a cycle of 10 years), and some negative sinusoidal change (with a cycle of 5 years). The slope of negative linear change is $15.98, and the amplitudes of sinusoidal changes are $76.31 and minus $12.23, respectively. The business cycle variables for lumber and ground wood pulp are similar to kraft pulp. Their effects, however, are somewhat different. Both the linear and sinusoidal changes are negative for lumber. This means that during the period under consideration the business cycle produced reductions in lumber values. However, business cycle effects for lumber are small relative to those of pulp. In the case of veneer and waferboard, changes in Residual Timber Value with time are characterized by only one sinusoidal curve. For both products the cycle spans six years. For veneer and plywood the amplitude is $252.47 and for waferboard it is $82.30. The effect of both the demand and supply side variables on the RTV's for all the five products is shown in Figures 6 to 10.

Figure 6.
Lumber Residual Value versus Total Distance from Mill
Tree Size = 0.5 m^3, Roughness Class = 3

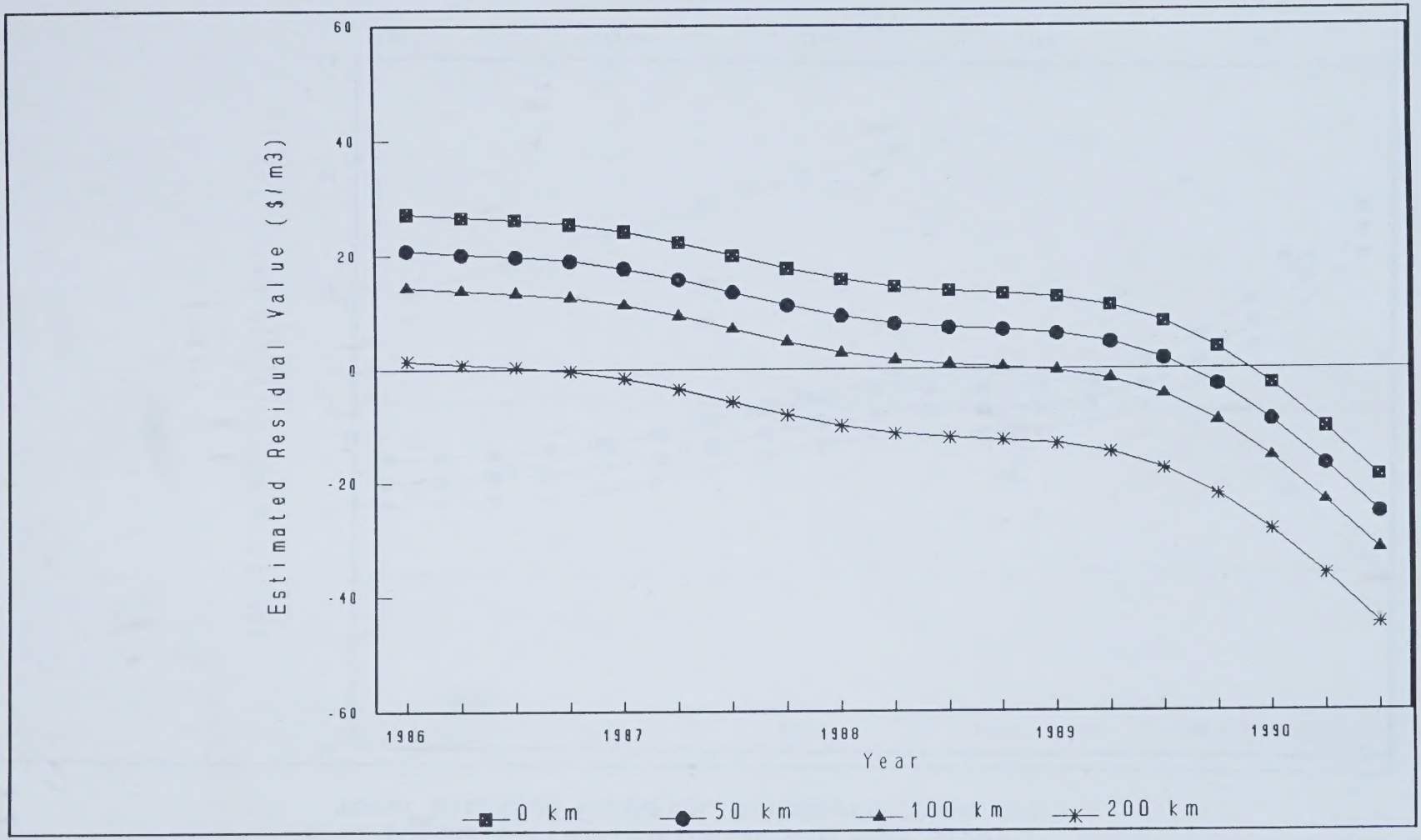


Figure 7.
Lumber Residual Value versus Tree Size
Total Distance = 100 km, Roughness Class = 3

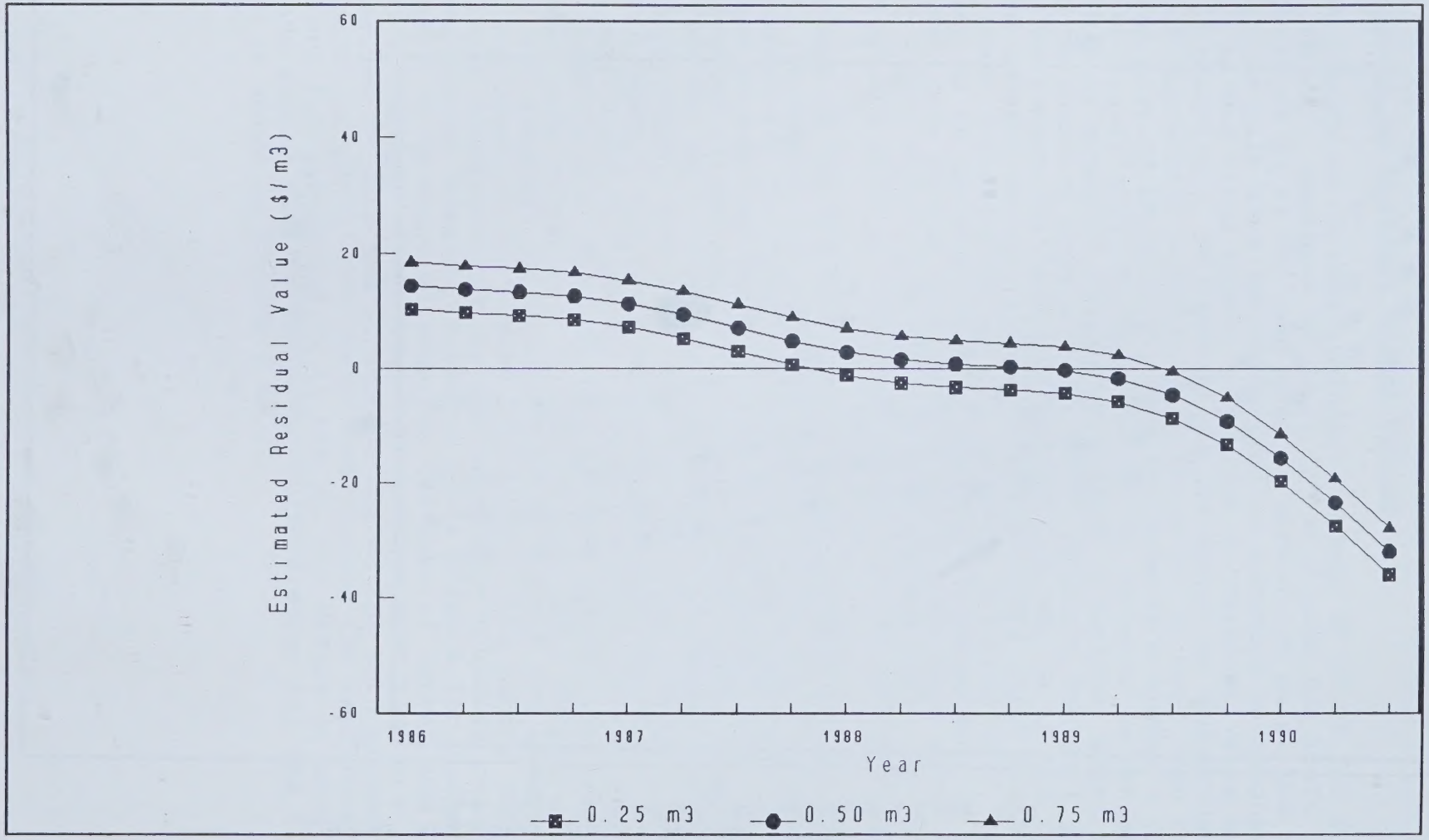


Figure 8.
Pulp Residual Values
Tree Size = 0.5 m^3, Roughness Class = 3, Total Distance = 100 km

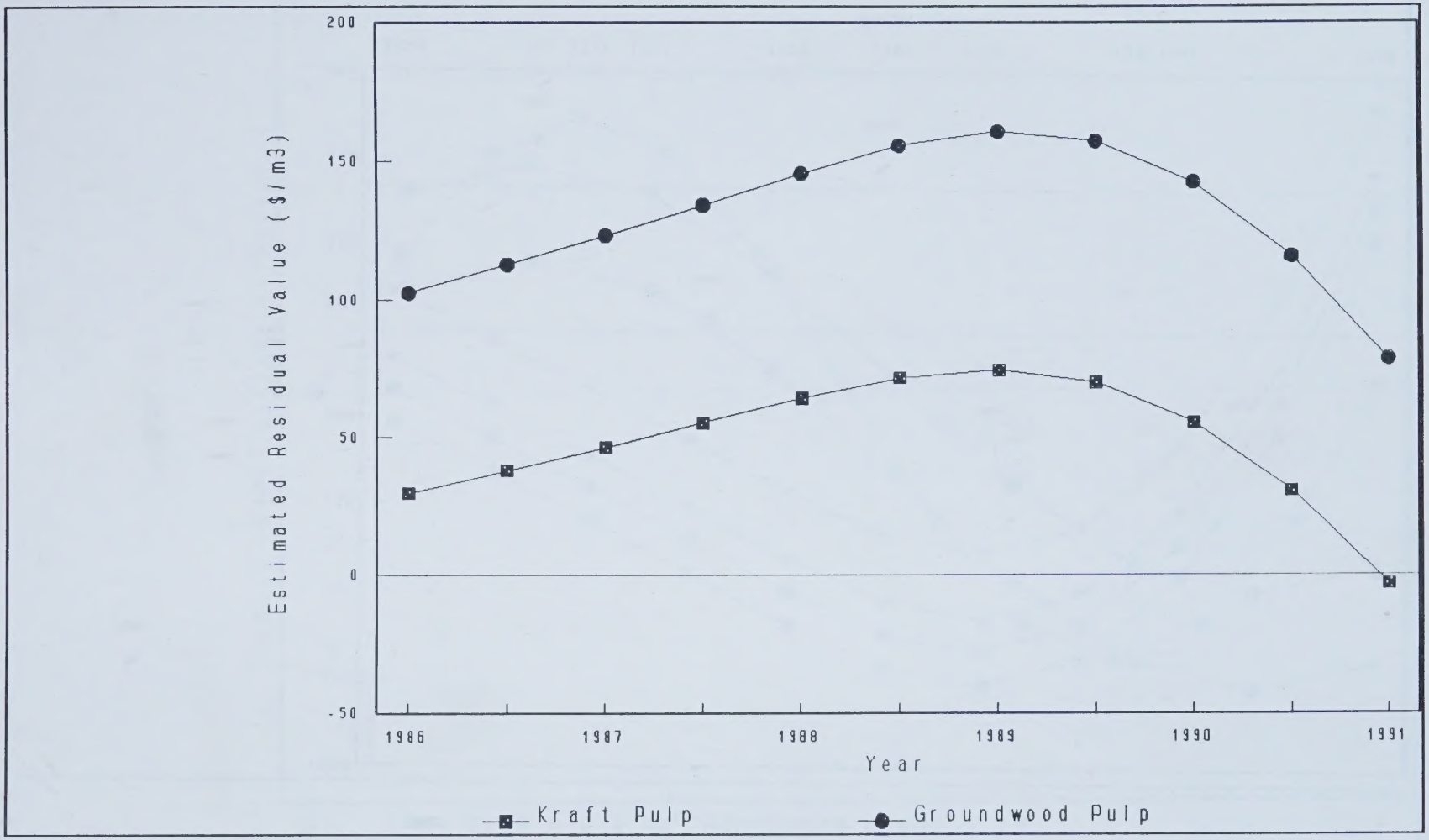


Figure 9.
Kraft Pulp Residual Value versus Total Distance from Mill
Tree Size = 0.5 m^3, Roughness Class = 3

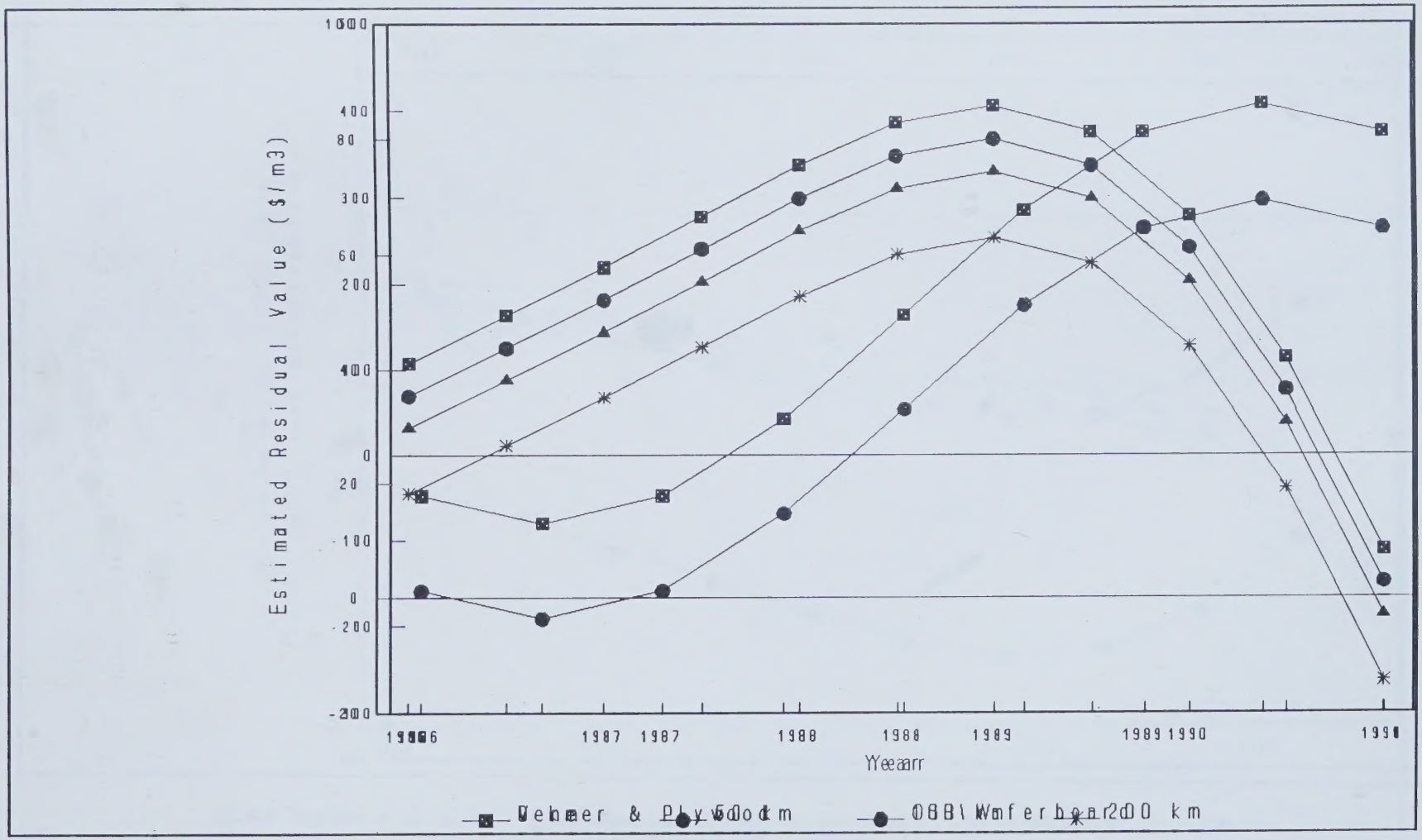
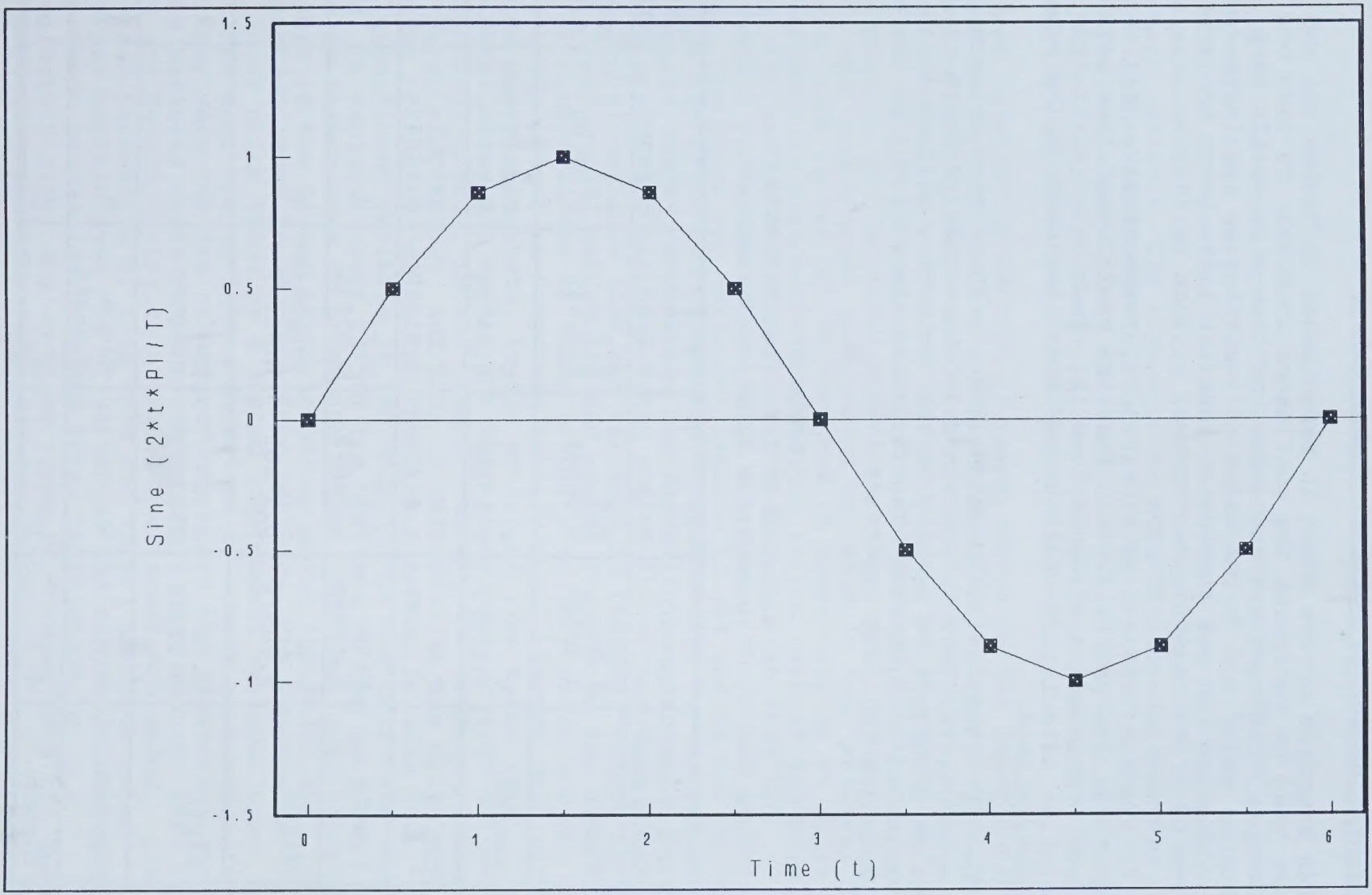


Figure 10.
OSB/Waferboard and Plywood & Veneer Residual Values



The standard errors shown in parentheses in Tables 11a and 11b are used to determine the confidence interval. To take one example, the standard error for the tree size coefficient in the lumber model is .787282 Value of t-statistics for large degrees of freedom for 95% confidence level is 1.96. Lower and upper limits of 95% confidence interval will be 16.381962-0.787282*1.96= 14.83888928 and 16.381962+0.787282*1.96=17.92503472, respectively. This means that one can be 95% certain that the coefficient lies between the lower value of 14.83888928, and the upper value of 17.92503472. A similar calculation could be performed for each of the other coefficients.

The next interesting question is how much of the variance in the dependent variable is explained in these models? Table 12 below gives a cumulative summary of the variance explained by the key variables in each case. The variables are ranked from the most important to least important.

Table 12
Adjusted R^2 for Final Variables
(Cumulative from top to bottom)

Order of Variables	Lumber	Kraft Pulp	Groundwood Pulp	Veneer & Plywood	OSB/Waferboard
First	T.D 0.49146	T.F 0.48646	T.F 0.63419	T.F 0.93989	T.F 0.97509
Second	t 0.81650	t 0.83158	t 0.86340	Underbrush 0.94927	T.D 0.98557
Third	T.S 0.86467	T.D 0.89606	T.D 0.91737	Height 0.95042	T.S 0.99094
Fourth	Slope 0.88844	T.F1 0.94270	T.F1 0.97710	0	0
Fifth	T.F 0.90524	T.S 0.97002	Roughness 0.98507	0	0
Sixth	T.F1 0.91385	Slope 0.97575	T.S 0.98782	0	0
Seventh	0	0	Slope 0.98945	0	0
Eighth	0	0	0	0	0

Where: T.D- Total distance, T.S- Tree size, T.F- $\sin(2\pi t/T)$, T.F1- $\sin(2\pi t/0.5T)$, and the linear price trend over time is

t.

Looking at the first model for lumber production, the R2 values in the table tell us that nearly 49 percent of the total variation in the residual value is accounted for by the change in the distance that the wood is transported. Adding the next most important variable, the linear price trend factor, brings the total variance accounted for to 81.65 percent; and addition of tree size and slope brings this total to 88.84 percent. Further, the inclusion of two sinusoidal variations in prices improves the explanation of variance to the level of 91.38%.

The most interesting feature of these models is the importance of the end product prices i.e., the demand side variables. With the exception of the lumber model, all product models show a very high percentage of variation in residual values accounted for by variation in end product prices. The independent variable corresponding to sinusoidal variation with a full business cycle is the most significant independent variable in four products and explains from 48.64% of the variance in kraft pulp to 97.5% of the variance in waferboard production. In the case of the pulp group, the second most important variable is also from the independent variables representing the variation in end product prices. The first two variables explain 83.15% and 86.34% of the variance for kraft and groundwood, respectively. For veneer and waferboard, only one variable corresponding to variation in end product prices explains more than 90% of the variance in residual value. This indicates that the variance in residual values of kraft, groundwood, waferboard and veneer depends on the demand side of market forces of these products to very great extent. But, it should not be forgotten that this will happen only in the case of volatile markets. In the period of time taken into consideration by the models for this study most product prices varied considerably. In the case of lumber, the price variations were relatively modest, and this is reflected in the different ordering of the variables for the lumber model. In this case, the most significant variable is the distance of the mill from the stand. It explains about 50% of the variance in the Residual Value of Timber used in producing lumber. The next most important variable is the linear trend in prices which increases the explanation level to nearly 82% of variance. The appearance of the linear price trend as a second independent variable also indicates that the variation in prices of lumber were more linear than they were for the other products where the sinusoidal change of the business cycle was dominating the linear change. When the third and fourth variables of the lumber model are added, i.e., the stand parameters of tree size and slope, the four major variables explain over 88% of variance. The sinusoidal changes in end product prices improves the total explanation by approximately 2.5%, and so these types of changes have not been very important for lumber in last few years.

Another interesting feature of these models is that out of mill

and stand parameters representing the supply side of market forces, the most important variable is the total distance of the stand from the mill. This variable is the most important one for lumber. In the case of kraft pulp, groundwood pulp, and waferboard also, it is the first independent variable from the supply side i.e., from the list of stand and mill variables which appears after the independent variables representing the changes in prices. Only in the case of veneer and plywood total distance does not appear as the most important independent variable after prices and its place has been taken by underbrush. For the pulp group, and for veneer & plywood, the second and additional variables from mill and stand parameters appeared after all the independent variables corresponding to price variations. For lumber, all of stand parameters appeared before the variables for price variations.

Clearly all the models have very high predictive capability. The waferboard model is the strongest in terms of overall predictiveness. But, it cannot be taken as the best model, because it is based on a very small data set, and that too only for two years. Out of the three models for lumber, kraft pulp and groundwood pulp which are based on large data sets, the best predictive model is for groundwood pulp.

It is interesting to note that several variables that might have been expected to be important did not prove to be significant in this analysis. Among these were gross merchantable volume (from Plonski's Normal Yield Tables) and site class. One likely explanation for this is that the quality of the site and its productivity are picked up in tree size.

In the preliminary model-building phase some independent variables were included which were later eliminated in the final models in order to make these models more general in application. One result of the earlier runs bears mentioning, however. In the initial year-wise analysis, MNR districts were introduced as "dummy variables" in the Northern Model. Some of these districts emerged as having an important impact on the residual timber values. These results are summarized in Table 13 below.

Table 13
Impact of Districts as Dummy Variables in Preliminary Runs

District	1986	1987	1988	1989	1990	1991
Nipigon	L,K,Gw -ve	L,K,Gw -ve	L,K,Gw -ve	K,Gw,V -ve L +ve	K,Gw,W -ve	
Red Lake		K,Gw -ve			K -ve Gw +ve	Gw -ve
Fort Frances		K -ve	K, Gw -ve	K +ve	K -ve	
Kirkland Lake			K, Gw -ve	L -ve		
Algonquin Park			L,K,Gw +ve	K -ve	L -ve	
North Bay				Gw +ve	K -ve	
Sault Ste.Marie			K, Gw -ve	L +ve	K, Gw +ve	
Wawa				L +ve	Gw +ve	
Thunder Bay					K -ve	K,Gw -ve
Dryden		K +ve				
Sioux Lookout		L +ve		L -ve	L +ve	
Kenora				L -ve		
Timmins				L -ve		
Cochrane					L -ve	
Sudbury					L -ve	

L- Lumber, K- Kraft pulp, Gw- Groundwood Pulp, V- Veneer, and W- Waferboard

There are two interesting features. One is that the districts appeared to have a significant effect on residual values mainly in two years i.e., 1989 and 1990. This may be due to specific price and cost structures at those points in time. The other is that Nipigon, Fort Frances and Red Lake appeared to influence values in more years than the others viz, 5, 4 and 3 years respectively. In most cases the effect of these districts on the

residual values was negative, although the results are somewhat confusing since each of these three districts shows a positive effect for one of the years.

Finally, it is worth noting that in some of the preliminary runs the type of logging system used had an effect on residual values. In general, Method 3 (cable skidder, 110 kw , feller- buncher, tree length stroke delimber and one-man slasher) produced the highest residual values, and Method 2 (Cable skidder 70 Kw, tree length stroke delimber, and one-man slasher) produced the lowest residual values. But, this was so only in a few of the equations.

Validation

Ten percent of the data were reserved in the beginning and later used for validating the model. The results of this validation test are given in Appendix 10.

A summary of the results of the validation test for different products is given in Table 14.

Table 14
Validation Results

Product	Test Data Sets	Data Sets With Confidence Number	in 95% Interval % of Total Data
Lumber	112	95	84.92
Kraft Pulp	340	316	92.94
Groundwood Pulp	147	146	99.31
Veneer & Plywood	16	16	100.00
OSB/ Waferboard	7	3	57.00

Sensitivity Analysis

After model estimation and validation, sensitivity analysis was conducted around key internal factors in the model.

One key decision in the use of the model is the choice as to how large the profit and risk factor will be. Profit targets within the forest industries vary. The user can be guided by targets used in other studies or in jurisdictions where residual timber value calculations form the basis for timber pricing. However, the choice is always somewhat arbitrary. One of the first priorities in this sensitivity analysis, therefore, was to establish the impact that variation in the profit and risk factor has on the Residual Timber Value. The base profit and risk factor in the model was 15%. A sensitivity analysis was performed by varying this factor to 10% and to 20%.

The second important choice in the design of the model was the decision to weight the non-highway distance to take into account the higher cost of non-highway transportation. This weighting factor (1.5 times the actual distance) was arbitrary. The model was run using 1.25 and 1.75 to determine how important it will be to establish the exact relationship between the transportation costs on highways and non highways .

Two important market variables are price of product, and cost of processing. Sensitivity analyses were conducted for 10 percent increase as well as decrease in prices and processing costs.

The results of these sensitivity analyses are given in Tables 15, and 16.

Table 15
Sensitivity Analysis
showing
Mean Residual Timber Values* for Different Products
with
Varying Profit Margins & Weights for Non-highway Distance

	Lumber	Kraft Pulp	Groundwood Pulp	Veneer & Plywood	OSB/Wafer board
Profit Margin (%)					
15	-11.69	40.84	117.20	393.31	10.78
10	-8.25 (+29.42%)	45.56 (+11.55%)	120.44 (+2.76%)	406.91 (+3.46%)	18.54 (+71.98%)
20	-15.14 (-29.51%)	36.13 (-11.53%)	113.97 (-2.76%)	379.70 (-3.46%)	3.03 (-71.89%)
Weight of Non-highway Distance					
1.50	-11.69	40.84	117.20	393.91	10.78
1.25	-10.76 (+13.08%)	41.79 (+2.33%)	118.19 (+0.84%)	394.24 (+0.08%)	11.13 (+3.25%)
1.75	-12.63 (-8.04%)	39.90 (-2.30%)	116.22 (-0.84%)	392.37 (-0.39%)	10.43 (-3.25%)

* The mean values are calculated over all years.

Table 16
Sensitivity Analysis
showing
Mean Residual Timber Values for Different Products
with
Varying Product Prices and Processing Costs

	Lumber	Kraft Pulp	Groundwood Pulp	Veneer & Plywood	OSB/Wafer board
Product Price					
Actual Market Price	-11.69	40.84	117.20	393.31	10.78
10% Increase	-4.93 (+57.8%)	57.52 (+40.8%)	137.37 (+17.2%)	463.93 (+18.0%)	29.71 (+175.6%)
10% Decrease	-18.45 (-57.8%)	24.17 (-40.8%)	98.04 (-16.4%)	322.68 (-18.0%)	-8.13 (-175.4%)
Processing Cost					
Actual Current Cost	-11.69	40.84	117.20	393.31	10.78
10% Increase	-15.25 (-30.45)	34.22 (-16.21)	114.43 (-2.37)	365.94 (-6.96)	-3.77 (-134.9)
10% Decrease	-8.14 (+30.37)	47.46 (+16.21)	119.98 (+2.37)	420.67 (+6.96)	25.35 (+135.1)

In general, the effect of change in any of the parameters on either side (increase or decrease) is symmetrical. Thus, both an increase and a decrease of 10% in prices of end products affects the RTV by more or less the same percentage (e.g., 58% for lumber).

The effects of a change in profit margin are very high in the case of waferboard (72%) and lumber (29%), moderate in the case of kraft pulp (11%), and very small for groundwood pulp and veneer & plywood (of the order of 3%).

The effect of a change in the weighting factor for non-highway distance does not seem very significant except in the case of lumber. This means that using a weighting factor between a range of 1.25 to 1.75 will not affect the values of RTV in any significant manner.

Changes in product prices show significant impacts on the RTV. For example, an increase of 10% in lumber prices increases the

RTV for wood used for lumber by about 58%. The effect of change in product prices is significant in all products, and the elasticity is greater than unity. In other words, a resultant percentage change in RTV is **larger** than the causative percentage change in product prices. It is highest in the case of wood used by the OSB/Waferboard industry where a 10% change in product prices produces a 175% change in RTV, and lowest for groundwood pulp (17%).

Changes in processing costs produce less pronounced results than changes in prices, but these are nonetheless of interest. A decrease in processing cost by 10% increases the RTV for wood used for lumber production by about 30%. The impacts in the pulp groups and for veneer and plywood are considerably smaller while the impact on waferboard and OSB RTVs is again high -- a 135% change in RTV produced by a 10% increase or decrease in production costs. RTV is less elastic to changes in processing cost than unity in the case of groundwood and veneer & plywood industries. This means that the resultant percentage change in RTV is **smaller** than the causative percentage change in processing cost in these two industries.

For a change of 10% in processing cost, the RTV's in the groundwood pulping industry change by about 2%, and in the veneer and plywood industry by about 7%. In the case of the other three products, the elasticity is more than unity, i.e., RTV's change by more than 10% when processing cost changes by 10%. The figures are -30% for lumber, +16% for pulp, and +135% for OSB/Waferboard.

CHAPTER 7 : SWOT ANALYSIS

The model has very high predictive capability, and low standard error. Validation results also indicate that the predicted RTV's of the 10% test data are very accurate, at least for four products: lumber, kraft pulp, groundwood pulp, and veneer and plywood. In the case of these four products, more than 80% of the test data fell within the 95% confidence interval of predicted RTV's. Only in the case of OSB/Waferboard, where there was a very small test data set, and where the estimations were based on a small data set, the validation results were not very good. But the adjusted R^2, even in this case were very high.

However, it cannot be taken for granted that the outcomes of the model will always be very good. The user must employ these models with full awareness of their strengths and weaknesses. Hence, a SWOT (**S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats) analysis is being done here.

Strengths:

1. The biggest strength of the whole study is not the actual configuration of the chosen models themselves, but the methodology developed during the process of model building. This methodology can be used on a very wide scale to get the residual timber values for any products, at any time, and at any place.

2. The second strength of this study is the incorporation of demand side variables, i.e., the nature of the business cycle in the Northern Model.

3. These are the very first models of this kind for Ontario. The models developed can be modified and revised with the availability of better data and can be periodically updated by incorporating up to date information.

4. Residual Timber Values can be estimated quite accurately by using a very small number of accurately measured stand and mill parameters and characteristics of the business cycle. The maximum number of stand and mill parameters required for the purpose is four for groundwood pulp, and the minimum is two for waferboard, and veneer & plywood. Therefore, the total process can be very cost effective.

Weaknesses:

1. Due to non availability of cruise and scaled volumes, Plonski volumes have been used in these models. These volumes are obtained from a general yield table and are not

necessarily accurate for specific stands.

2. The actual logging cost data were available only for one year (1987) and, therefore, costs for different years have been estimated by using an index. This process may not have been able to give accurate logging cost during different years.

3. Transportation cost data were also available for only one year (1988), and that too for only two firms. The conversion of this transportation cost by using a general transportation index for different years may also not have been able to provide the realistic estimations of transportation costs.

4. Price and cost data are not very accurate. In particular, groundwood pulp data are based on a very crude estimate relative to kraft pulp prices. Also, veneer & plywood prices used are based on export figures while the local market figures might have been substantially different. Only veneer prices for softwoods were known. The cost figures are for softwoods as well as hardwoods and these are for the combined veneer and plywood industry. The different sizes of veneer and plywood are not considered. Due to these severe data problems the reliance that may be put on the models for this product is extremely limited.

5. The actual processing cost figures for OSB/waferboard are also for one year. For calculating the processing costs for other years, an arbitrary index was developed. So, these costs may not be very reliable.

6. The absolute numbers given by models may not have much meaning because of the difficulties in obtaining actual processing and logging costs that are known only to the industry. These numbers are most meaningful only when seen in the relative sense. For example, one can get an idea of the change in relative values of RTV during different years for the same product, or relative RTV for wood used for different purposes.

Opportunities:

1.Refinement of Model:

Models developed can be refined by-

a. Incorporating accurate data for stand parameters like cruise and scaled volume. Since the data for past years is not easily available, it can only be done by taking care for collection of such data in future.

b. Incorporating the correct data for prices of groundwood, veneer & plywood, and processing costs for

all products. This can be done, only when the industries are willing to provide the actual data. In particular information on the prices of hardwood lumber, veneer and plywood will permit more realistic treatment of both the models.

2. Updating of Model:

The models can be updated every year by incorporating the data for that year.

3. Iso-RTV Maps:

With the help of these models iso-RTV maps can be prepared. These maps will show the forest areas from where equal Residual Timber Values may be expected. They can prove to be useful tools for planning silvicultural operations and for prioritizing areas and species for management purposes.

Threats:

1. If the models are not used properly they may prove not very useful and as a result the whole process of employing such devices as decision making aids may suffer a set back.

2. If updating and refinement of the models is not done in a systematic and sustained manner, the effort made in this first attempt may be lost and development of more sophisticated decision support systems thwarted.

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